NOVEMBER 1955

Journal

VOL. 47 • NO. 11

AMERICAN WATER WORKS ASSOCIATION

In this issue

Journal

AMERICAN WATER WORKS ASSOCIATION

521 FIFTH AVE., NEW YORK 17, N.Y. • Phone: MUrray Hill 2-4515

November 1955

Vol. 47 • No. 11

Contents

Departments

HARRY E. JORDAN, *Secretary*

LAWRENCE FARBER, *Managing Editor*

ERIC F. JOHNSON, *Asst. Secy.—Publications*

DONALD A. NELSEN, *Assistant Editor*

Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 521 Fifth Ave., New York 17, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918. $7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—60 cents; single copies to nonmembers—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*. Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

AWWA Officers and Directors

President	FRANK C. AMSBARY JR.	*Past-President*	M. B. CUNNINGHAM
Vice-President	PAUL WEIR	*Treasurer*	WILLIAM W. BRUSH
Ch. W.W. Practice Com.	LOUIS R. HOWSON	*Secretary*	HARRY E. JORDAN
Ch. W.W. Admin. Com.	WENDELL R. LADUE	*Exec. Asst. Secretary*	RAYMOND J. FAUST
Ch. Publication Com.	RICHARD HAZEN	*Asst. Secretary—Pub.*	ERIC F. JOHNSON

Officers of the Sections

Section	*Director*	*Chairman*	*Vice-Chairman*	*Secretary-Treasurer*
Alabama-Miss.	T. H. Allen	J. L. Haley	W. U. Quinby	C. W. White
Arizona	R. G. Baker	G. T. Rekerdre	M. V. Ellis	Q. M. Mees
California	B. S. Grant	L. J. Alexander	W. R. Seeger	H. F. Jerauld
Canadian	C.G.R.Armstrong	A. H. R. Thomas	V. A. McKillop	A. E. Berry
Chesapeake	D. V. Auld	J. C. Tracey	B. L. Werner	C. J. Lauter
Cuban	G. A. Bequer H.	E. E. Trelles	J. A. Vila	L. H. Daniel
Florida	W. W. Gillespie	D. W. Jones	J. R. Kelly	H. T. Skaggs
Illinois	E. E. Alt	C. C. Abplanalp	G. L. Davis	D. W. Johnson
Indiana	C. E. Williams	G. G. Fassnacht	E. Robbins	R. J. Becker
Iowa	C. W. Hamblin	D. L. Bragg	P. H. Morgan	J. J. Hail
Kansas	H. W. Badley	G. D. Pelton	B.H.Van Blarcum	H. W. Badley
Kentucky-Tenn.	C. H. Bagwell	J. J. Davis	R. A. Fischer	J. W. Finney Jr.
Michigan	L. E. Ayres	C. R. Erickson	W. E. Smith	T. L. Vander Velde
Missouri	H. O. Hartung	E. G. Lee	F. J. McAndrew	W. A. Kramer
Montana	C. W. Eyer	J. H. Morrison	B. F. Chestnut	A. W. Clarkson
Nebraska	R. H. Lancaster	E. B. Meier	W. J. Sommers	J. E. Olsson
New England	F. P. Stradling	H. H. Potter	J. H. Robinson	G. G. Bogren
New Jersey	G. D. Norcom	M. Brunstein	H. M. Ohland	C. B. Tygert
New York	J. C. Harding	E. C. Rowley	F. D. Behan	K. Blanchard
North Carolina	W. M. Franklin	S. E. Harris	R. S. Phillips	W. E. Long Jr.
North Central	L. N. Thompson	L. H. Coult	H.H.Behlmer	L. N. Thompson
Ohio	C. E. Beatty	D. D. Heffelfinger	M. W. Tatlock	M. E. Druley
Pacific Northwest	C. C. Casad	C. V. Signor	C. R. Harlock	F. D. Jones
Pennsylvania	L. S. Morgan	F. S. Friel	B. F. Johnson	L. S. Morgan
Rocky Mountain	G. J. Turre	J. O. Jones	Harry Barnes	J. W. Davis
Southeastern	S. Russell	B. J. Sams	C. C. Lanford	N. M. deJarnette
Southwest	J. R. Pierce	J. E. Williams	J. H. O'Neill	L. A. Jackson
Virginia	E. C. Meredith	G. H. Ruston	H. F. Knoell	J. P. Kavanagh
West Virginia	W. S. Staub	C. B. Whitlock	C. C. Coffield	H. W. Hetzer
Wisconsin	J. C. Zufelt	B. J. Hartman	J. E. Kerslake	L. A. Smith

Directors Representing the Water and Sewage Works Manufacturers Assn.

CARL N. BROWN   EVERETT M. JONES   Robert F. Orth

Officers of the Divisions

Division	*Chairman*	*Vice-Chairman*	*Secretary*
Water Works Management	D. L. Erickson	L. W. Grayson	W. W. DeBerard
Water Resources	B. S. Grant	H. C. Barksdale	C. H. Bechert
Water Purification	H. C. Medbery	H. H. Gerstein	P. D. Haney
Water Distribution	F. E. Dolson	H. W. Niemeyer	E. S. Cole

LIST OF ADVERTISERS

Directory of Professional Services—pp. *53-58 P&R*

AWWA DIAMOND JUBILEE CONFERENCE

St. Louis, Mo. **May 6-11, 1956**

All reservations will be cleared through the AWWA office. The nine official hotels have agreed to accept no reservations for the 1956 Conference except as they are requested on the standard form, through the AWWA. Forms are being mailed to members in November.

Coming Meetings

AWWA SECTIONS

Nov. 6–9—Florida Section, at Orange Court Hotel, Orlando. Secretary, Harvey T. Skaggs, Secy. & Gen. Mgr., Amica Burnett Chem. Co., Box 2328, Jacksonville.

Nov. 14–16—North Carolina Section, at Robert E. Lee Hotel, Winston-Salem. Secretary, W. E. Long Jr., 1615 Bickett Blvd., Raleigh.

Dec. 1–3—Cuban Section, at Cuban Society of Engineers, Havana. Secretary, L. H. Daniel, Box 531, Baratillo 9, Havana.

1956

Jan. 17—New York Section Midwinter Luncheon, at Park Sheraton Hotel, New York. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand St., White Plains.

OTHER ORGANIZATIONS

Nov. 14–18—American Public Health Assn. Convention, at Municipal Auditorium, Kansas City, Mo.

Nov. 16–18—Water Works Management Short Course, at Univ. of Illinois, Allerton Park, Ill.

Nov. 21–22—Hydraulics Conference, at Continental Hotel, Kansas City, Mo., sponsored by Kansas City Section, American Society of Civil Engineers.

Nov. 27–30—American Institute of Chemical Engineers, at Hotel Statler, Detroit, Mich.

Nov. 27–30—National Chemical Exposition, at Public Auditorium, Cleveland, Ohio, sponsored by Chicago and Cleveland sections, American Chemical Society.

(*Continued on page 8*)

Coming Meetings

(Continued from page 6)

Dec. 5–9—Exposition of Chemical Industries, at Commercial Museum and Convention Hall, Philadelphia, Pa., under management of International Exposition Co., New York.

1956

Feb. 13–18—Symposium on Winter Concreting Theory and Practice, International Union of Testing & Research Labs. for Materials & Structures (RILEM), Copenhagen, Denmark. Organizing Secy., RILEM Symposium 1956, c/o Danish National Inst. of Building Research, 20 Borgergade, Copenhagen, K, Denmark.

Jun. 17–23—World Power Conference, Vienna, Austria. Oesterreichisches Nationalkomitee der Weltkraftkonferenz, Vienna I, Schwarzenbergplatz 1.

Nuclear Engineering and Science Congress Cleveland, Ohio, Dec. 12–16, 1955

The Congress, to be held at Cleveland's Public Auditorium, is sponsored by Engineers Joint Council, with AWWA and other organizations cooperating. An International Atomic Exposition, sponsored by American Institute of Chemical Engineers, will also be held at the Public Auditorium, Dec. 10–16. AWWA-sponsored papers to be presented at the Congress on Thursday and Friday, Dec. 15 and 16, are listed below:

Instrumentation for Radioactive Pollution Studies—A Survey by AWWA Task Group 2630 P........ HAROLD E. PEARSON

Use of Portable Instruments for Detection and Monitoring of Emergency Levels of Radioactivity in Waters........ SIMON KINSMAN

Measurements of Radioactivity in Water........ L. R. SETTER & A. S. GOLDIN

Radiochemical Techniques for Separation of Radioisotopes........ BERND KAHN

Removal of Radionuclides From Water by Water Treatment Processes........ ROY J. MORTON & CONRAD P. STRAUB

Mixed-Bed Ion Exchange for the Removal of Radioactivity........ H. GLADYS SWOPE

Processing of High-Level Atomic Wastes With a View to Ultimate Disposal........ L. P. HATCH & W. H. REGAN JR.

Decontamination of Radioactive Water Supplies... ROLF ELIASSEN & ROBERT A. LAUDERDALE

Ultimate Disposal of Radioactive Reactor Wastes in the Oceans........ CHARLES E. RENN

Status of Soil Disposal for Reactor Wastes........ ARNOLD B. JOSEPH

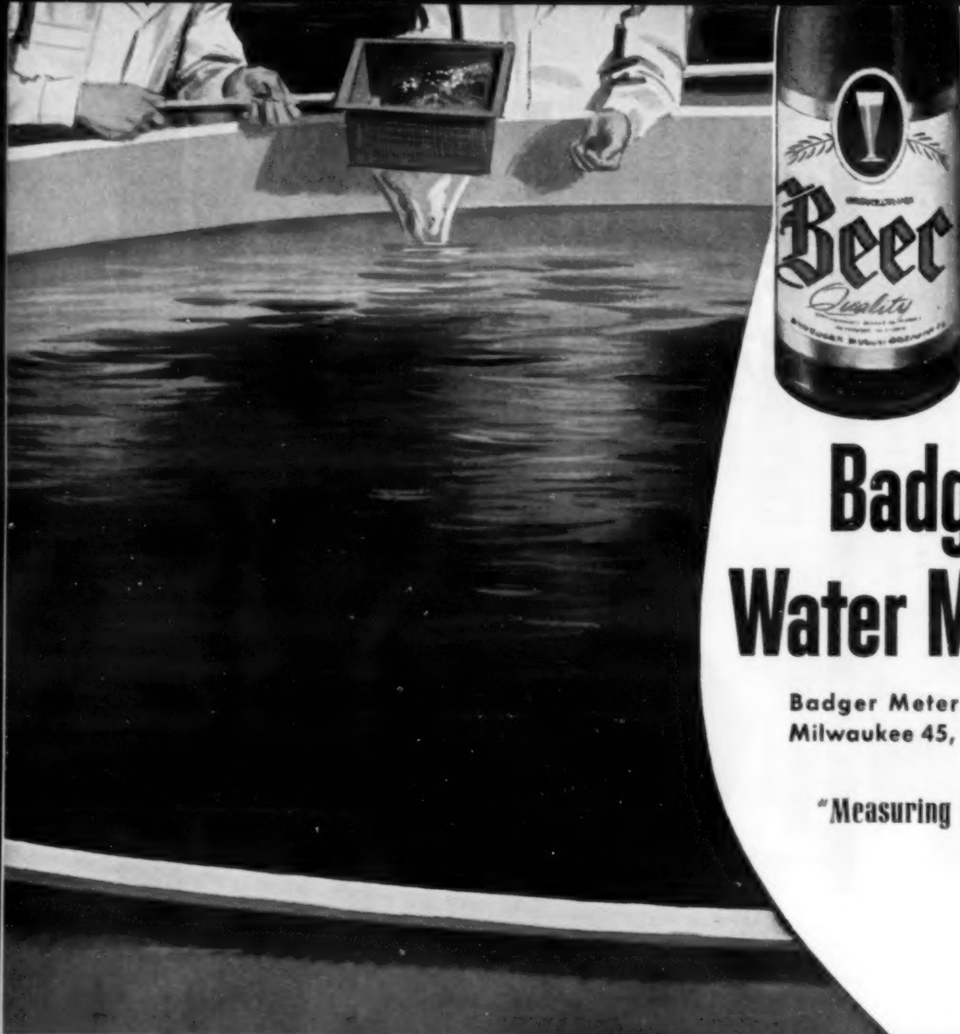
Long-Range Fallout in Surface Water Supplies........ C. G. BELL JR.

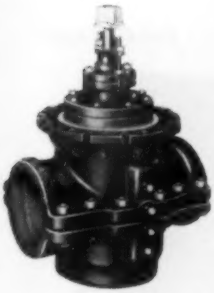
Maximum Permissible Levels of Radionuclides in Air and Water........ K. Z. MORGAN

AEC Fallout Monitoring Network........ MERRIL EISENBUD

Emergency Maximum Permissible Concentration Values in Water........ CONRAD P. STRAUB

Biological Methods for the Removal of Radioactivity From Liquids.... WILLIAM E. DOBBINS


Beer
Quality

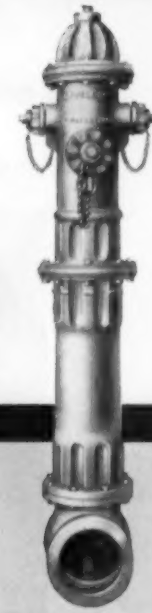


Inserting Valves

Designed for adding needed control valves without hazardous shutdown . . . quickly installed in line under pressure . . . operated like standard gate valve . . . working parts interchangeable with AWWA gate valve . . . sizes 4", 6" and 8".

Curb Stops

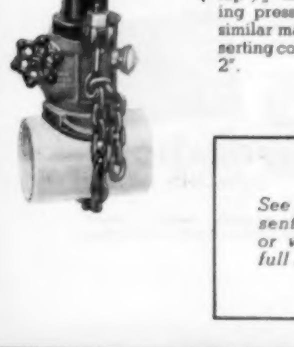
Ground key construction . . . precision fitted and individually lapped . . . proper taper of key assures easy operation and long life . . . inverted key or solid head type . . . complete range of sizes, types and connections.



Demands for better water works equipment to meet growing water works needs, coupled with the Mueller policy of constant product improvement and development, have resulted in the new and vastly improved products shown. These products are just a portion of the complete selection of water works equipment, supplies and specialties offered by Mueller Co. and manufactured to characteristically high standards. All Mueller products are fully tested and warranted.

Fire Hydrants

Improved design incorporates all the latest hydrant features . . . compression-type main valve . . . safety flange and stem coupling . . . "O" ring stem seals . . . self-oiling reservoir . . . double drain valves . . . dry top design . . . now available with "Ring-Tite" inlet connection.

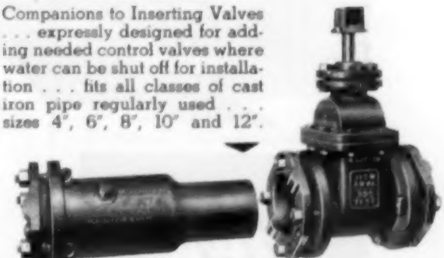


"B" Tapping Machine

Drills and taps mains and inserts corporation stops, ½" through 1", under pressure . . . will dry tap ½" through 2½" . . . working pressure to 230 p.s.i. . . . similar machine available for inserting corporation stops through 2".

Cut-In Sleeves and Valves

Companions to Inserting Valves . . . expressly designed for adding needed control valves where water can be shut off for installation . . . fits all classes of cast iron pipe regularly used . . . sizes 4", 6", 8", 10" and 12".

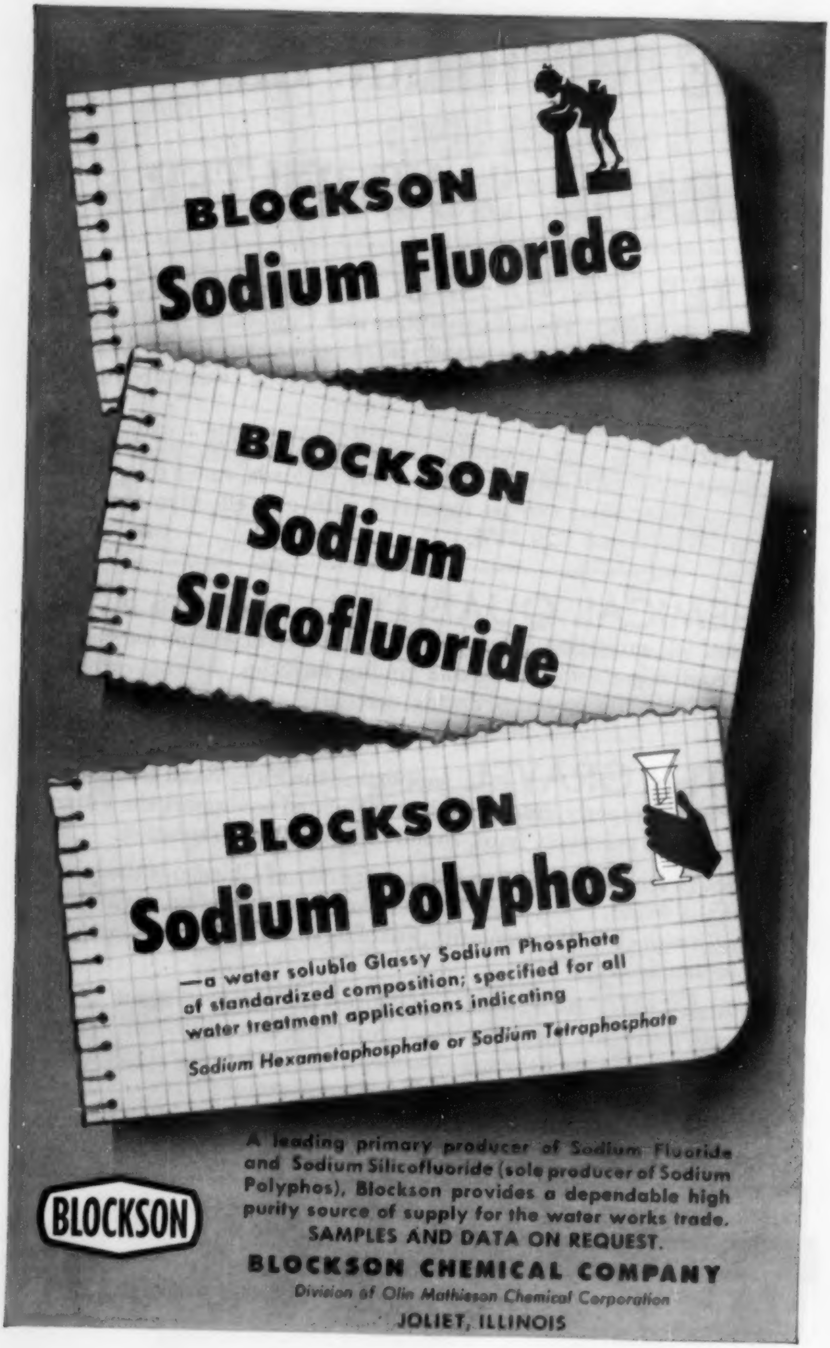


See your Mueller Representative, Catalog W-96 or write direct today for full information.

MUELLER CO.

Dependable Since 1857

MAIN OFFICE & FACTORY DECATUR, ILLINOIS


BLOCKSON
Sodium Fluoride
BLOCKSON
Sodium
Silicofluoride
BLOCKSON
Sodium Polyphos
—a water soluble Glassy Sodium Phosphate of standardized composition; specified for all water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate
A leading primary producer of Sodium Fluoride and Sodium Silicofluoride (sole producer of Sodium Polyphos), Blockson provides a dependable high purity source of supply for the water works trade.
SAMPLES AND DATA ON REQUEST.
BLOCKSON
BLOCKSON CHEMICAL COMPANY
Division of Olin Mathieson Chemical Corporation
JOLIET, ILLINOIS

Consulting Engineer L. W. Veigel

SPECIFIES

INERTOL® COATINGS

throughout new

2-MGD WATER WORKS,

Dickinson, North Dakota

Torex® Enamel, in Sea Green No. 304, protects submerged surfaces of filter beds against water and water treatment chemicals. Photograph shows E. A. Tschida, Plant Superintendent, checking filter valves.

SPECIFICATIONS FOR TOREX ENAMEL:
A glossy, chlorinated natural rubber-base coating . . . fade-resistant. For submerged surfaces of concrete and steel in water works.

Concrete Surfaces:
Colors: Color Chart 560. **No. of coats:** One TOREX Enamel over one TOREX Undercoater. **Coverage:** 250 sq. ft. per gal. per coat. **Approx. mil thickness per coat:** 1.0. **Drying time:** 24 hours between coats; 7 days before submerging. **Primer:** TOREX Undercoater. **Thinner:** Inertol Thinner 2000. **Application:** Apply to etched concrete. **Brushing:** As furnished. **Spraying:** Add sufficient Inertol Thinner 2000 (10 to 50%). *(Write for* TOREX *steel-surface painting specifications.)*

● In addition to TOREX ENAMEL, Consulting Engineer Veigel specified: colorful RAMUC® UTILITY ENAMEL, chlorinated natural rubber-base, for nonsubmerged masonry; GLAMORTEX® ENAMEL, mar-resistant alkyd, for nonsubmerged metal to be painted in color; INERTOL No. 49 Thick, long-wearing asphaltic coating, for submerged metal where black bituminous paint is suitable.

Inertol coatings have met the requirements of hardness, elasticity and chemical inertness in water works throughout the country. That's why Mr. Veigel chose them for the city of Dickinson, a growing farm and mining community with a prosperous future.

Buy Inertol paints direct from the manufacturer. Shipment within three days from our plant, or from nearby warehouse stocks. For full information about Inertol coatings, write today for free "Painting Guide."

Ask about Rustarmor,® Inertol's new hygroscopically controlled rust-neutralizing paint.

Inertol

INERTOL CO., INC.

A COMPLETE LINE OF QUALITY COATINGS FOR SEWAGE PLANTS & WATER WORKS

484 Frelinghuysen Avenue
Newark 5, New Jersey

27 G South Park
San Francisco 7, California

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 47 • NOVEMBER 1955 • NO. 11

Improvement of the Chicago Water Works System

James W. Jardine

A paper presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill., by James W. Jardine, Comr., Dept. of Water & Sewers, Chicago, Ill.

As commissioner of water and sewers since Jan. 1, 1953, the author has spent most of his waking hours in providing for the present and future needs of the systems. Background information is necessary for a fair picture of the scope and complexity of the activities of the Chicago Dept. of Water and Sewers. In December 1952, the city council passed a reorganization ordinance regrouping into departments what are commonly known as the public works functions. A new water and sewers department was established and made responsible for the operation and maintenance of the Chicago water works and sewer installations. With one exception, all responsibility for engineering, design, and construction of capital improvements in both systems was placed with the Bureau of Eng. in the Dept. of Public Works. Capital improvements in the water distribution system, however, was assigned to the water and sewers department. This organization is not out of contact with the other water works capital improvement projects inasmuch as it initiates them and works very closely with the engineers from the planning stages through to completion.

Departmental Units

The department is separated into two major units—the Bureau of Water and the Bureau of Sewers. The latter has under its jurisdiction about 3,600 miles of sewers. The former, serving approximately 341 sq miles, including 51 suburbs with a population of 4,400,000, employs more than 2,600 persons. The Bureau of Water consists of five operating divisions:

1. Collection Div.—responsible for rate assessing, meter reading, billing, and collecting, and accounting for water charges from about 461,000 ac-

counts providing an annual revenue of more than $30,000,000

2. Distribution Div.—responsible for engineering, design, construction, and maintenance of the distribution system, which consists of more than 4,000 miles of water mains, 41,800 valves, and 44,121 hydrants; in 1954, the division designed and constructed about 29 miles of new mains of all sizes

3. Meter Div.—responsible for the control, maintenance, and replacement of approximately 126,000 meters, involving both shop and field work.

4. Pumping Stations Operation Div. —responsible for the operation of four lake intake cribs, eleven pumping stations, and one power plant; 371,118 mil gal were pumped in 1954, with an average of 1,016 mgd.

5. Purification Div.—responsible for water safety control activities and the operation and maintenance of the world's largest filtration plant, which serves the south side of the city; a filtration plant with about three times the capacity is now under construction to serve the north and central sections.

Rise in Water Use

Inasmuch as Chicago is situated on Lake Michigan, water problems are not related to supply but to distribution, a fact that has focused the department's attention on the operation and maintenance of pumping stations and the construction and maintenance of the system of mains. Most of the water works officials and engineers who, in the last two generations, planned and constructed the intakes, tunnels, and pumping stations in use now, are no longer living. But the city is still benefiting from the results of their courage, vision, and wise judgment which provided the facilities that furnish fairly adequate service 25–40 years later. Present-day management, in keeping with the example set by its predecessors, is, to the limit of its ability, actively engaged in providing additional installations to take care of current needs, as well as the future requirements of Chicago and its rapidly growing suburbs.

The modern trend in Chicago, as in other large metropolitan areas, is toward more comfortable living conditions, which, naturally, has resulted in a more liberal use of water. Although this situation has caused only a small rise in average consumption, a very significant increase in peak water demand often occurs. Furthermore, the demands are considerably higher than were anticipated in most conservative estimates made in the past. In order to meet such peaks, it is necessary to provide a greatly increased water works plant, much of which may be operated less than 5 per cent of the time. Although this state of affairs may or may not be economically feasible or practical, in the author's opinion a water utility must have the facilities to satisfy the greater consumption due to community growth and changes in community habits. Because there has been a sizable movement of the population of the metropolitan area to the periphery of the water works system within the city and in the suburbs, additional installations are necessary to get the water to these outlying sections. It has been necessary, therefore, to give considerable emphasis in planning to the furnishing of additional mains, pumps, and other equipment for this purpose.

Capital Improvements

Based on known needs, a water works capital improvement construction program for 1956–60 has been prepared, calling for the expenditure of about $125,000,000. The construction being carried on during 1955 will amount to approximately $21,000,000. A total of 38 miles of feeder mains, 24 in. in diameter and larger, will have been built during the 3-year period ending Dec. 31, 1955. This amount is about 250 per cent of the mileage of feeder mains laid in the previous 10 years. Many of these projects have been for the purpose of reinforcing the distribution facilities serving outlying areas. The bureau is now completing the modernization and enlargement of the equipment in the five major steam-operated pumping stations. Obsolete and inefficient pumps are being replaced with modern, high-efficiency, steam turbine-driven centrifugal pumps of larger capacity than the previous mechanisms.

At present, Chicago has in operation one filtration plant supplying approximately 33 per cent of the population. Construction has been started on another installation on 61 acres of filled-in land at the lake shore. This plant, three times as large as the older one, will have a rated capacity of 960 mgd and a maximum capacity of 1,400 mgd and will be able to furnish filtered water to the rest of the city after completion in 1960.

The anticipated construction of a 30-mil gal ground reservoir adjacent to a pumping station will provide immediate aid in meeting the additional needs of the rapidly growing southwest section of the city, particularly during peak demands, and will help to average up the operating load of the presently existing filtration plant. Long-range plans have also been developed for the construction of a 16-ft tunnel, 4 miles long, to meet the future demands of the southwest area. The sum of $15,000,000 has been appropriated for this project, which will probably be completed in 1958 or early 1959.

Future Demand

Engineers of the Distribution Div. are making studies to determine the demands that will be placed on the system during 1960–80. A considerable portion of these will come from outside the corporate limits. Water is now furnished to about 51 suburbs, whose requirements will probably increase. Chicago will be called upon to supply other suburbs and outlying areas, because their water tables are already low and are going lower, and the ground water will soon be insufficient.

Predictions of future needs, therefore, must take into account the entire metropolitan area, which includes a considerable section outside Chicago and Cook County. For these and other reasons, a firm of consulting engineers has been retained to make a study and submit a report covering their conclusions as to the future needs of the Greater Chicago metropolitan area until 1980. This statement will estimate future requirements both in and outside of Chicago and will include an estimate of the necessary additional facilities. The consultants, together with the engineers of the Distribution Div., are expected to provide a complete basis for developing intelligent plans for the coming years. L. R. Howson's paper (*this issue, p.* 1038)

presents material on the forecast of metropolitan Chicago's water needs.

Also expected to take place in the future is the improvement of many supporting activities and facilities, such as the meter shop, field operations, water safety control, cribs and intakes, and revenue billing and collection. The overall plan could not be considered complete if it covered only the physical plant. In a large utility, methods, techniques, and controls must keep pace with modern developments. A great deal of thought, therefore, has been given to the modernization and improvement of the manner in which the work of the water department is done. For example, starting in the fall of 1954, the accounting and billing were changed from a manual procedure to an electric, high-speed punch card machine system, including the use of post card bills. It is anticipated that this conversion will not only result in a saving in the operation itself, but will also furnish information that will be of inestimable value to engineering planning.

Safety Program

A valuable and indispensable resource is competent and adequate manpower, which is difficult, and sometimes impossible, to replace. It is necessary to make the most effective use of the available labor, and to do everything possible to protect the members of the work force. Early in 1954, therefore, a comprehensive safety program was put into effect, covering all of the various activities of the water department. In addition to the preparation and distribution of manuals of safety rules and regulations covering safe work practices for all operations, the issuance of a periodic safety bulletin, and research on modern safety equipment, this plan provided for a department-wide safety organization consisting of safety engineers and committees, composed of both line and staff personnel, at the various organization levels. Detailed accident data for all operating units in the department should also be kept. The program has been in operation only for about 2 years, but its value has already been proven by a reduction in the accident injury frequency and severity rates. The average country-wide injury rates for water utilities in 1954 (*1*) showed that there was a frequency of 19.76 and a severity of 0.95, whereas the Chicago water works injury rate had a frequency of 9.91 and a severity of 0.38.

Administration Changes

Another step, taken late in 1953 in the interests of tightening up the organization, was the establishment of an Operating Methods Section to analyze and evaluate practices and operating methods on a continuous basis in an effort to improve them wherever possible. This departmental aim has the enthusiastic endorsement and support of the mayor, whose interest in the development of the most efficient and economical procedures is a strong incentive to better performance. After a careful study, it was found that organization and methods could never remain static if the most effective job is to be done. Experience has shown that —given an opportunity for continuous study and the use of ingenuity—operating methods and organization practices can be improved, with a consequent reduction in cost per unit of production.

The establishment of the operating methods program was not a new idea, as it has been used as a tool of management for many years. Generally speaking, it has been very difficult to get operating personnel to evaluate without bias the practices governing their operation. For this reason, such responsibility was given to a specialized group. It has not been easy to staff the Operating Methods Section because it is difficult to find persons who have the aptitude and qualification for such work. This unit, however, has already had a modicum of success, and further accomplishments are expected. In addition, this section has undertaken the preparation of written manuals of standard operating practices for the various activities of the department, a lengthy job which sorely needs doing.

It was decided in 1953 to change the format and composition of the department's annual report, which in earlier years had been a voluminous compilation of data that were of concern primarily only to technicians and water works operators. It was felt that there was need for a statement that would be of interest to the citizens of Chicago, giving them easily assimilated information about the operation of the public water and sewer systems. The report is now a pictorial narrative presentation for general distribution to give Chicago water consumers a better understanding of their water works and of the round-the-clock service received daily from the department. Supplements presenting technical and statistical data on the operations of the system are available on request.

Reference

1. 1954 Utility Safety Record. *Jour. AWWA*, 47: 762 (Aug. 1955).

Forecast of the Needs of the Chicago Metropolitan Area

L. R. Howson

A paper presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill., by L. R. Howson, Partner, Alvord, Burdick & Howson, Chicago, Ill.

As a prelude to a discussion of metropolitan Chicago's future water needs, it may be helpful to review the city's experience in meeting similar situations in the past.

The Chicago Board of Trustees held its first meeting on Aug. 12, 1833. The unincorporated community had been afflicted with a cholera epidemic the previous year. Dr. Daniel Drake thought it might have been caused by the plowing of the prairies but suggested that uncleanliness and lack of sanitation were also contributing factors. There was no public water supply until 1840, when a private concern called "The Hydraulic Co." was organized to take water from Lake Michigan about 600 ft off shore. This company accomplished little in the 11 years of its existence and, when taken over by the city in 1853, possessed only a single 25-hp pumping engine and 2 miles of wooden pipe, serving a relatively small area in which there were few consumers.

When the city started water works operations, it had a population of 30,000 and an area of 14 sq miles. In the next 100 years, the population served by the Chicago water works increased to 4,286,000, the region within the corporate limits expanded to 213 sq miles, and water was furnished to a large outlying area. A 3-year typhoid epidemic just prior to the Columbian Exposition resulted in nearly 4,500 deaths, leading to the passage of the Sanitary District Act of Chicago by the state legislature in 1889. In the next two decades, the district reversed the flow of the Chicago River, diverted sewage outfalls from the lake to the river and drainage canals, and materially improved the quality of the supply.

The act contained a provision that outlying communities included within the limits of the Chicago Sanitary Dist. should have access to the municipal water supply at the Chicago city limits at the same rates and under the same conditions as the urban residents. Nearly 600,000 people in 51 suburbs outside of the city are now served with Chicago water.

Sources of Supply

Chicago has always taken its supply from Lake Michigan. As shore pollution increased, the city attempted to secure better quality by placing the intakes farther out in the lake. The first intake, located just 600 ft from shore, was lengthened to 2 miles in 1867. Later, this and other such installations were extended to cribs located 3–4 miles off shore in 40–50 ft of water. The pumping stations on the lakeside, as well as those inland, are connected to the cribs by rock tun-

nels usually about 150 ft below the water surface.

To understand the Chicago metropolitan area supply situation, it must be recalled that, initially, all of the suburban sections, other than those fronting on the lake, obtained their water from wells, which originally had artesian flow to about 100 ft above the ground surface. Heavy pumping has lowered the level in the sandstones to approximately 500 ft below ground surface at the present. This rapid subsidence, averaging 5–10 ft per year, has progressively caused the suburbs to avail themselves of the Sanitary District Act's provision by which they can secure city water.

Facilities

The Chicago intake system now has a total capacity of about 2 bgd. It is interesting to note that the construction of filtration facilities which can satisfactorily purify water drawn through shore ports will probably deter the further extending long lake intakes. The use of filtration has thus reversed the effort of nearly 100 years to protect water quality at Chicago by fabricating the longest possible intakes.

From the water works operating standpoint, Chicago is divided into three tunnel districts, each supplying several pumping stations, of which there are eleven major ones at present. The capacity of the pumping stations is 2.61 bgd. Two-thirds of the stations are powered by electricity and one-third by steam, a division providing a factor of safety guaranteeing continuity of service. Because the system does not have elevated storage, continuous operation in spite of electricity failures is particularly important.

Prior to the completion of the 320-mgd South District Filtration Plant after World War II, Chicago used only chlorination for its water supply treatment. Anticipating the employment of filtration, Chicago had set up an experimental plant in 1927. After the South District Filtration Plant began operation, other sections demanded improved water quality. An engineering study made to determine the most practical method of supplying the two-thirds of the city not then furnished filtered water recommended the construction of a single, gigantic plant, which would have a capacity of 960 mgd and which would be located on reclaimed land occupying an area of 61 acres within a cofferdam on the lake bottom. Work on the installation, estimated to cost about $100,000,000, was begun after lengthy hearings and litigation. The cofferdam enclosure is now nearing completion. The new plant and the old will serve filtered

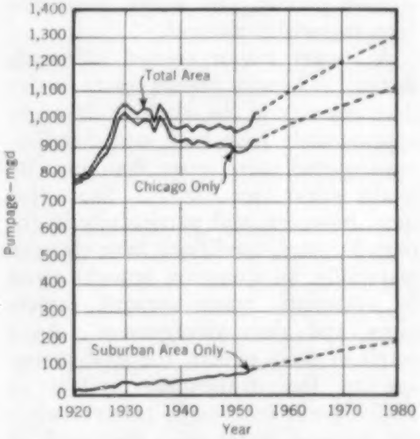


Fig. 1. Annual Average Daily Pumpage

The data presented are for the present service area only. The figures for 1920–54 were taken from the annual report of the Chicago Dept. of Water and Sewers. The forecasts were made by Alvord, Burdick, and Howson.

water of the highest quality to all Chicago and its suburbs.

Metering

At present, Chicago supplies water through approximately 465,000 individual services, of which 26.9 per cent are metered. The percentage of services metered has changed little in the past two decades, but the percentage of water sold through meters and the revenue from such disposal has increased greatly, and water waste has been materially reduced.

A former mayor erected billboards stating "Chicago pumps more water than any city in the world." It might appropriately have been said that Chicago wasted more water than any city in the world (see Fig. 1). Since that time, however, and particularly in the past 20 years, conditions have changed materially, an alteration brought about by systematic waste surveys, inspections, and alert management. As a result of these efforts, the total pumpage to the distribution system in 1940–50 was reduced 1½ per cent while the metered water sales increased 28 per cent, unmetered water use decreased 21 per cent, and the revenue from metered sales rose 46 per cent. The city now realizes approximately $6,000,000 per year by selling 150 mgd that was formerly unaccounted for. Chicago still pumps more water than any other city in the world, but that supply today generally is being advantageously used and is revenue producing.

Shortages

Each of the organized communities within the sanitary district served by Chicago provides its own connection to the municipal system, either individually or in conjunction with others. The connection is made at the city limits, where Chicago's responsibility terminates.

The summer of 1953 was hot and dry in the Chicago area. The total annual rainfall was only 10 per cent below normal but a record-breaking heat wave started in early May and extended through most of September. During that period, there was one in-

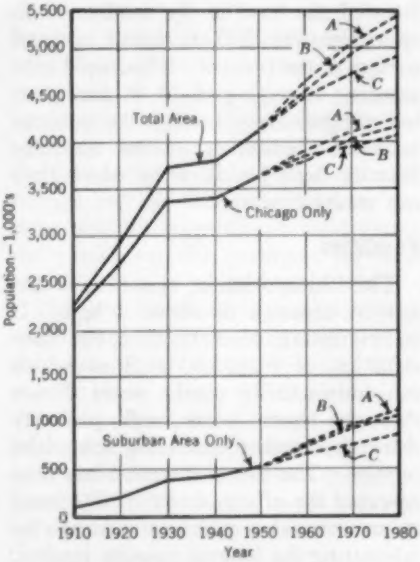


Fig. 2. Population Forecasts for Present Water Service Area

A—*Alvord, Burdick, and Howson, September 1954;* B—*Chicago Regional Planning Assn., Aug. 30, 1954;* C—*Chicago Water Distribution Div., Jun. 25, 1954. Data to 1950 were supplied by US Census Bureau.*

terval of 20 days when there was no rain at all, and the number of days on which the maximum temperature exceeded 90°F surpassed all previous records. This state of affairs occurred at a time when there was an unprecedented building of homes and growing of new lawns and resulted in a serious

deficiency of supply in the suburban areas.

There was no raw-water shortage; Lake Michigan, the Chicago tunnel system, pumping stations, and, in most areas, the distribution system were generally adequate, although a number of localities on the Chicago system had pressures as low as 10 psi. Some suburbs, however, were completely without water, a situation resulting from inadequate transportation facilities, largely in the connections leading from the Chicago city limits to the outlying communities.

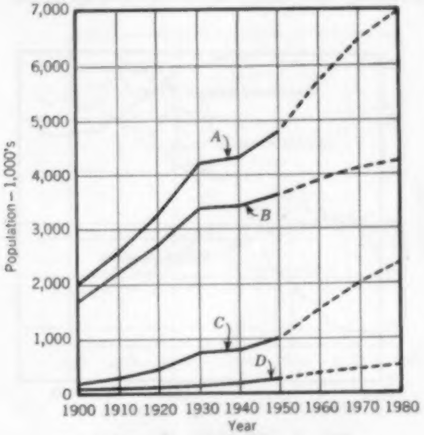


Fig. 3. Population Forecasts for Chicago Metropolitan Area

A—*Chicago metropolitan area;* B—*Chicago;* C—*suburban incorporated communities;* D—*unincorporated areas. Data to 1950 were supplied by US Census Bureau. Forecasts based on those of Alvord, Burdick, and Howson, Chicago Regional Planning Assn., and Chicago Water Distribution Div.*

The contracts that Chicago has with the suburban communities possess the general requirement that they must furnish storage on their systems equal to at least one average day's supply. More than 75 mgd of storage, therefore, is located in the various outside localities, which now use an average of approximately 88 mgd. Another provision allows Chicago to shut off service to the suburbs between 6 and 10 PM, thus requiring them to draw on storage during that period. Although the city has never enforced the stipulation, it has been observed voluntarily by some of the suburbs.

Forecasts for Future

The water shortages, which were particularly acute in the suburban areas, made it apparent that something had to be done. Chicago employed the firm of Alvord, Burdick, and Howson to study the future water requirements of the entire metropolitan region radiating approximately 40 miles in all directions from the center of the city, in order to ascertain the water requirements, to outline the most practicable means by which the area could be supplied with Lake Michigan water by the Chicago water works system, to estimate the costs incident to such expansion of facilities, and to determine the economic practicability of adequately supplying not only the 51 communities now served with Chicago water, but also all of the communities in the entire metropolitan region. This inquiry was to be made beyond the limitations imposed by the Sanitary District Act of 1889 and the political subdivision boundaries in order to determine the economic feasibility of centralized water supply service. The investigation was completed during the summer of 1955.

The present is a difficult time in which to forecast the population of metropolitan areas. The Chicago metropolitan area, like many others, is experiencing a phenomenal growth, much of which, at least percentagewise, is taking place outside of the city limits.

Between 1870 and 1930, the Chicago population increased by an average of 500,000 per decade and at a relatively consistent rate. In the next two decades, the rise was only 125,000 per decade and from 1950 to 1980, according to estimates, it will not exceed 200,000 per decade (Fig. 2).

The suburban population now served with Chicago water increased by 102,684 from 1940 to 1950, and by 83,000 in the next 3 years. In the entire metropolitan area, the population of incorporated communities, approximately 500,000 in 1920, increased to nearly 1,200,000 by 1950 and will probably reach about 2,750,000 by 1980 (Fig. 3). In addition, there has been a large development in presently unincorporated localities, the population of which will probably reach 500,000 in the next 25 years. Thus, while Chicago is expected to gain 600,000 persons in the next quarter of a century, the outlying parts of the metropolitan area will acquire about 2,000,000.

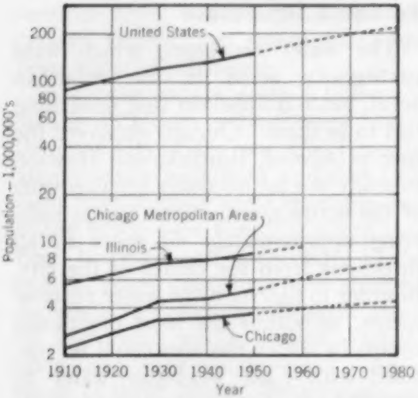


Fig. 4. Population Forecasts for United States, Illinois, and Chicago

Data to 1950 were supplied by US Census Bureau. Forecasts for the United States and Illinois were made by US Census Bureau. Forecasts for Chicago and its metropolitan area were made by Alvord, Burdick, and Howson.

The population of metropolitan Chicago is not only growing, it is shifting, a fact that has an important bearing upon the supply problem of the region. A study of population increases for the past 40 years (Fig. 4) discloses a striking similarity between the growth of the United States, Illinois, the Chicago metropolitan area, and Chicago. All four have substantially paralleled each other. Based on a careful study of past growth, it is believed that the population of the Chicago metropolitan water service area will reach approximately 7,000,00 in 1980. Of this number, about 60 per cent will live in Chicago; and the remaining 2,710,000 will dwell in suburban communities. At present, nearly 600,000 of the suburbanites are served with Lake Michigan water through the Chicago system.

Fig. 5. Metering Increase

Chicago has been doing a very efficient job of waste detection and correction since 1935. Water that was formerly unaccounted for now produces a revenue of about $6,000,000 a year.

Suburban communities that are not furnished with Lake Michigan water generally secure their supplies either from deep sandstone wells, which generally are available throughout the entire suburban areas at depths of 1,500–2,100 ft, or from shallow Niagara limestone wells, which are practicable in only a limited locality about 10 miles wide and 50 miles long.

Fig. 6. Average Daily Per Capita Rates of Pumpage

During 1930–50, Chicago's average daily per capita usage dropped about 20 per cent, while the suburban use rose approximately the same percentage. All data are for the present service area only.

In estimating the future water requirements of the Chicago metropolitan area, separate studies have been made for Chicago and for individual suburbs. Analysis of Chicago operations discloses that since 1935 the city has been doing a very efficient job of waste detection and correction (see Fig. 5). This procedure has been so effective that with no increase in the percentage of services metered since 1935, the total pumpage registered on meters has increased from 30 to nearly 53 per cent and the percentage of pumpage which is not metered, including that consumed by flat-rate services, leakage, and "free" and "unaccounted for" water, has been reduced by one third in the same period.

Analysis of the uses of both Chicago and its suburbs makes it seem likely that their present average daily requirement of approximately 1 bgd will increase to 1.35 bgd by 1980. It is interesting to note in this connection that

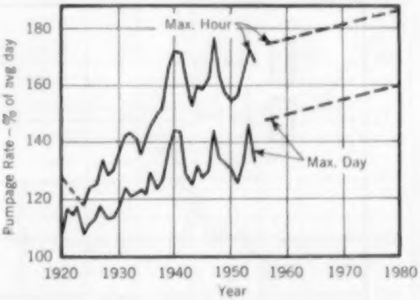


Fig. 7. Maximum and Average Pumpage

Shown above are the ratios of the maximum hour and maximum day to the average day. All data for the present service area only.

during the period in which Chicago's per capita use has decreased from approximately 302 gpcd to about 240 gpcd (about 20 per cent), the suburban per capita use has increased by approximately the same percentage (Fig. 6). If Chicago is to meet the demands of the entire metropolitan area, the city must be capable of producing an average of approximately 1.5 bgd by 1980.

Maximum Requirements

Although the average day's use is the basis of revenue, it is the maximum day's requirements that is the measure of adequacy and that determines capital expenditures. Because, in gen-

eral, approximately 50 per cent of the cost of water results from fixed charges, the effect of the maximum day's use on capital outlay is directly reflected in the cost of water. At Chicago, as elsewhere, recent years show a marked rise in the ratio of the maximum day to the average day and of the maximum hour to the average day (Fig. 7). The ratios at Chicago in comparison with many other cities are still low. The ratio of the maximum day to the average day at Chicago has increased almost 1 per cent per year for the last 10 years and is now approximately 150 per cent. During the same period, the ratio of the maximum to the average hourly requirement has increased 1½ per cent yearly and is now approximately 175 per cent. It is believed that these ratios will continue to rise at Chicago even though the suburban supply is restricted by contract to the average rate of the maximum day. The increase in the ratio of the maximum day to the average day is believed to be caused by many factors, including greater use of water for air conditioning, growing and maintaining new lawns, and operating garbage grinders, automatic washing machines, and other household devices.

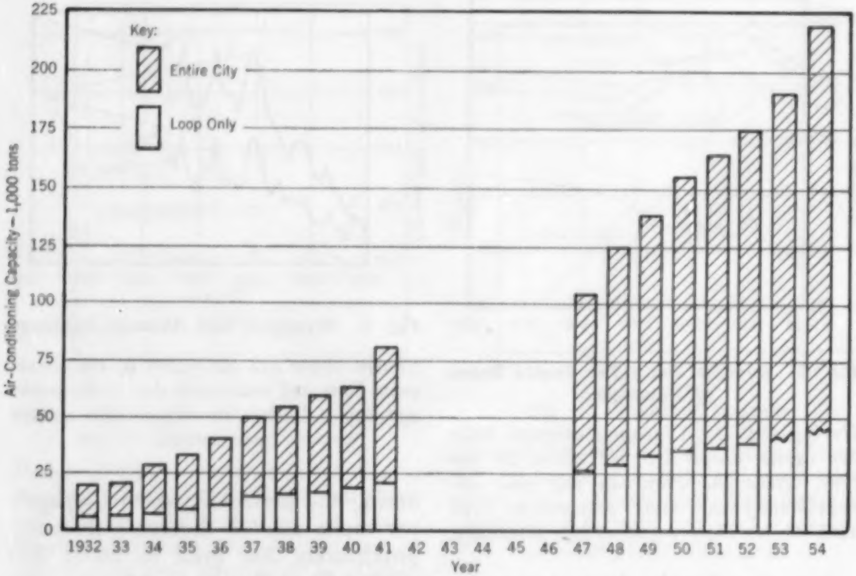


Fig. 8. Estimated Water-Cooled Air Conditioning in Chicago

No data were available for World War II. The amount of air conditioning has increased steadily year by year. The estimated water-cooled refrigeration in use in 1954 amounted to 200,000 tons.

Studies made by the water department indicate the rapid growth in tonnage of water-cooled air conditioning in Chicago (Fig. 8). In 1954 alone, 28,000 tons was installed. The assistant chief water engineer of Chicago has examined the effect of the various

elements contributing toward peak day and peak hour requirements (Fig. 9). Fortunately, the air-conditioning use reaches its maximum before 5 PM, whereas lawn sprinkling and open hydrants reach their peak demands after that hour.

The "normal" average day peak rate of about 1.2 bgd is increased in midafternoon on hot days approximately 200 mgd by the air-conditioning load. On a hot day in a dry period, the peak rate is nearly 1.7 bgd, which ordinarily occurs from 7–8 PM, after the air-conditioning load has decreased about 150 mgd, and results from lawn-sprinkling and open-hydrant demands of about 450 mgd. If the air-conditioning and lawn-sprinkling loads coincided in point of time, the peak rate of pumpage would be approximately 10 per cent higher.

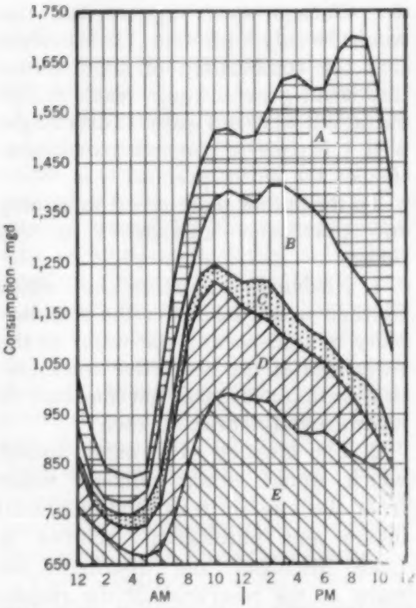


Fig. 9. Peak Hour and Peak Day Factors

A—*lawn sprinkling and open hydrants;* B—*air conditioning;* C—*extra summer refrigeration;* D—*industrial and extra weekday use;* E—*minimum day.*

The growing spread between the average day and the maximum day must be reflected in revenues (see Fig. 10). For illustration, a 25 per cent increase in peak rates may raise the costs of the source of supply and the purification plant by 25 per cent and cause a 50 per cent pressure drop in tunnels and feeder mains, thus requiring higher pumping heads, larger mains, distribution system storage, or combinations of such expediencies. The tendency toward higher maximum days must be recognized and provided for. It is believed that the maximum-day water requirement in the Chicago metropolitan area for communities now

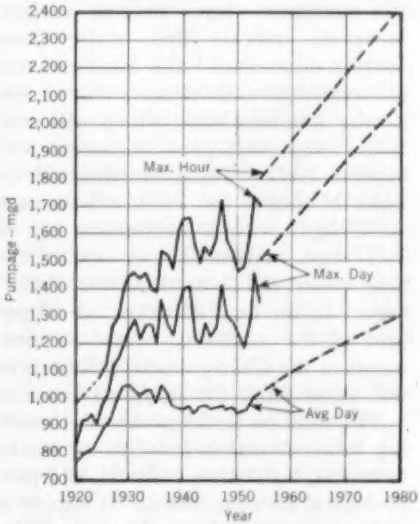


Fig. 10. Maximum and Average Pumpage

There is an increasing spread between the maximum hour and day and the average day. All data are for the present ice area only.

served will reach approximately 2.102 bgd by 1980. If the entire Metropolitan area is to be furnished water by Chicago, more than 2.400 bgd will be required by 1980.

Conclusions

The water requirements for the entire Chicago metropolitan area for 1980 are estimated to be 1.489 bgd for the average day and 2.409 bgd for the maximum day. Present studies, however, indicate that water from sources other than Lake Michigan will be available and cheaper for many nearby municipalities, which will continue using their present sources well beyond 1980. Thus, the demand on Lake Michigan for 1980 will average 1.378 bgd, with a maximum day of 2.217 bgd. About 25 per cent of the total water will be used outside of Chicago. In the next 25 years, 33–50 per cent of the additional water requirements of the Chicago metropolitan area will come from the outlying districts.

The solution to the problem of meeting future demands involves economic, technical, legislative, political, and psychological factors. As far as supply is concerned, Chicago, whose facilities now furnish water to more than two-thirds of those outside of the city who want lake water, can readily and economically serve the metropolitan area. Under present legislation, however, the city delivers only to its limits, and the 51 suburban communities transport the water the rest of the way. This procedure has proved uneconomical and has proved unsatisfactory and will probably continue to be so.

It is common experience that the development of an entire metropolitan area can be better anticipated and provided for than the individual growths of a large number of communities. It is also well known that already established, centralized operations can be expanded by a few per cent with much more assurance of satisfactory results than can be secured from providing multiple facilities with wide ranges in individual demands. For illustration, a 100 per cent increase in a suburb of 50,000 would involve a staggering expenditure for that locality whereas to the Chicago water system the rise would be only 1 per cent. It is evident that the combination of communities into small groups would result in few extra benefits, and such efforts might well postpone a comprehensive solution of the entire problem.

To the author there seems to be only two practicable alternatives at this time:

1. Enabling legislation by which Chicago would take over the responsibility of transporting the water to the reservoirs of the respective communities, with rates based on the cost of facilities and service to each.

2. The creation of a water district which would either purchase water from the city or construct individual intake and purification facilities at Lake Michigan and distribute the water to the reservoirs of the respective communities under the preceding conditions.

Any satisfactory solution must be based on sound engineering and economic considerations. Fortunately, there is no supply problem at Chicago, inasmuch as purification is relatively simple and adequacy is essentially determined by the transportation facilities. These will be better designed and operated under centralized responsibility than under individual municipalities.

Pumping Stations in Residential Areas

Joint Discussion

A joint discussion presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill.

Long Island, New York—Peter Ley

A paper presented by Peter Ley, Vice-Pres. & Chief Engr., Jamaica Water Supply Co., Jamaica, N.Y.

THE part of Long Island served by the Jamaica Water Supply Co. provides a typical example of a suburban area where postwar growth has created serious water problems. The locality served by the company consists of 40 sq miles, partly in the borough of Queens in New York City, and partly in the adjacent section of Nassau County. Not many years ago, this locality contained only quiet residential communities and open, truck-farming country. Today, huge housing developments, which cover hundreds of acres, blanket the area. Population has risen by almost a third in the past decade and is expected to continue increasing in the foreseeable future.

The company's new customers are, typically, fathers of young families with fairly comfortable incomes. They have left New York in order that their children might have grass and trees and more space in which to play. Like most first-time homeowners, they are house-proud and devoted to their gardens. Their wives are busy young mothers who welcome every new labor-saving device that appears on the market. As a result, their homes are loaded with water-consuming comforts and gadgets, such as second bathrooms, automatic laundries, dishwashing machines, garbage disposal units, and air conditioners; and their lawns are dotted with sprinklers and children's swimming pools. Despite an enormous appetite for water, especially in the summertime, these recent suburbanites are so proud of their new homes and communities that they want nothing—least of all an old-fashioned water works—to "spoil the neighborhood."

If a note of bitterness has crept into this description of typical Suburbia, it is not intended as criticism. On the contrary, the management of the company believes, quite sincerely, that its customers are not unreasonable in their demands and that it is the duty of a public utility to provide the kind of service its customers desire, insofar as possible. The company has made a determined effort to do this. Under the active direction and leadership of its president, Daniel J. Hennessy, supply has been greatly increased during recent years, utilizing a completely fresh approach to the problem of design and appearance of pumping and storage facilities.

Expansion for Increased Demand

At present the company serves approximately 107,000 customers (about

500,000 people). More than 90 per cent of the accounts are residential consumers who live in one- or two-family homes. The rest are apartment houses and commercial or industrial establishments. Supply is obtained entirely from wells within the franchise area.

In the past 10 years, the company has doubled its plant investment. The biggest spurt in new construction was begun in 1952. In 1953–54 thirteen new wells, four new storage tanks, and a considerable amount of related equipment were placed in service, increasing the available supply by almost 40 per cent. The 67 wells now in operation have an authorized capacity of 93 mgd; 27 storage tanks have a capacity of 24 mil gal. Seven more wells to be completed in 1955–56 will raise well capacity to 106 mgd. The available supply will then be almost 60 per cent greater than in 1952. The distribution system consists of 779 miles of main, with an average diameter of slightly more than 8 in. Telemetering and remote control are used to a major extent to start and stop distant pumps, operate valves, and transmit pressure and tank water elevation.

Although average daily pumpage has gone up at a fairly uniform rate during the past 10 years, closely approximating the annual increase in the number of customers, the summer demand has risen much more steeply. During July 1954 the average daily pumpage was 152 per cent of the annual daily average, and the maximum day was 30 per cent higher than in 1952. On the maximum day in 1954, the pumping rate during a 10-hr period was 250 per cent of the annual daily average, and, during 1 hr, the rate rose to 300 per cent of the daily average for the year.

These summer demands do not reflect completely unrestricted use of water. From Jun. 1 to Sep. 30 hose use is restricted to a total of 5 hr daily during the early afternoon and late evening, when there is no conflict with peak demand for regular domestic and business use. Compliance with this rule has been quite good. In 1954–55 the company conducted a concentrated campaign of publicity, advertising, and consumer education on lawn sprinkling, along with an enforcement drive which proved highly effective. Without such effort, even the greatly augmented supply available in 1954 would have fallen short of peak demand.

Problems in Residential Areas

Prior to 1952 the design of supply and storage structures was mainly utilitarian. Stations were often built in open country where development areas had been subdivided but where there was, as yet, little residential construction. Typical of the company's facilities at that time was a plain, box-like structure with brick walls and reinforced concrete roof and floors (Fig. 1). Storage structures were the conventional elevated tank or standpipe.

In 1952 it became necessary to acquire a number of sites for the new wells and tanks scheduled for the 1953–54 expansion program. By that time, however, very little vacant land which met the requirements for well and tank sites remained. Present health department regulations specify that where sanitary sewers are not available for connection to building drainage systems, a minimum distance of 100 ft must be maintained between a well and an adjacent property line; where sewers have been installed, there must be a minimum of 100 ft between the sewer and the well. The available sites

meeting these requirements were almost all in built-up residential neighborhoods. In some instances, it was necessary to buy property with a dwelling already on it and then tear it down.

One of the first projects to be undertaken was the installation of two wells and a 1-mil gal storage tank in Floral Park, a high-value residential suburb in Nassau County. Although the local citizens very much needed and wanted more water, they were distinctly cold to the idea of having the necessary structures within their community. Original plans called for a partially underground type of pumping station and a tank 108 ft in diameter with a cone- or dome-shaped roof. The total shell height of 16 ft plus the roof was to be above grade.

There was immediate opposition to these plans. Not only did nearby residents protest, but the entire community became so aroused that the local zoning board refused a building permit. It was obvious that an entirely different approach would have to be devised if the company were to succeed in building the needed facilities. Management also realized that more was involved than a pumping station in one community. This was an issue which threatened the relationship of the company as a utility, with its public and might seriously affect the future expansion of the entire system.

Fig. 1. Typical "Old-fashioned" Installation

These structures were built before the beautification program was begun.

Acceptable Water Facilities

As a first step, the executives of the company met with Floral Park officials and civic leaders to ask their advice

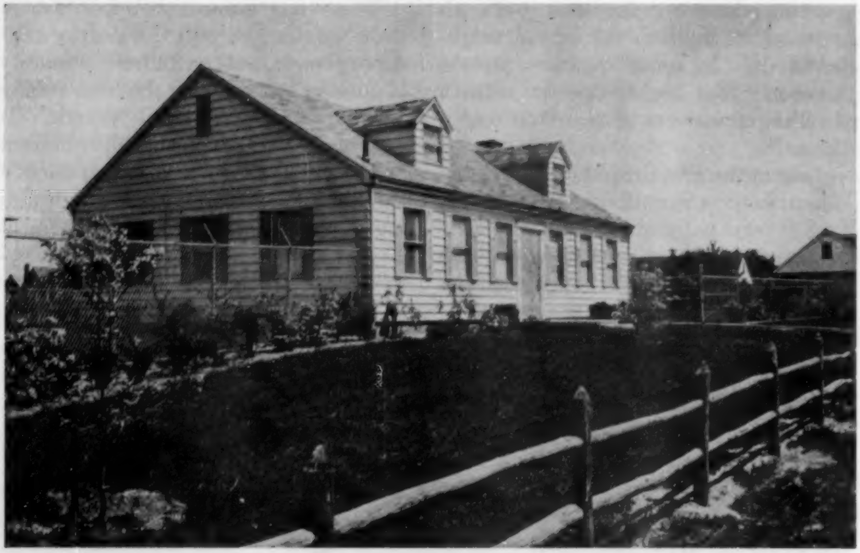


Fig. 2. Floral Park Station

This was the first of the new structures designed for suburban residential areas.

Fig. 3. Partly Underground Pumping Station

This installation is used extensively in semicommercial and lower-cost residential areas.

and cooperation in developing a type of structure that would be fully acceptable. For the first time a utility was asking, not telling, them. This change in tactics alone had a most beneficial effect on public attitudes. Next, a study of the prevailing architecture of the community was made. Plans were then developed for a building which met all functional requirements but, on the outside, was indistinguishable

The entire plot is attractively landscaped and has rustic fencing along its front lawn.

When this station was completed, the largest daily newspaper in the area carried a picture of the building over a lead editorial with the headline: "Beauty Comes to the Water Works." The article praised the company for its imaginative and enlightened policy and urged other utilities to follow this example.

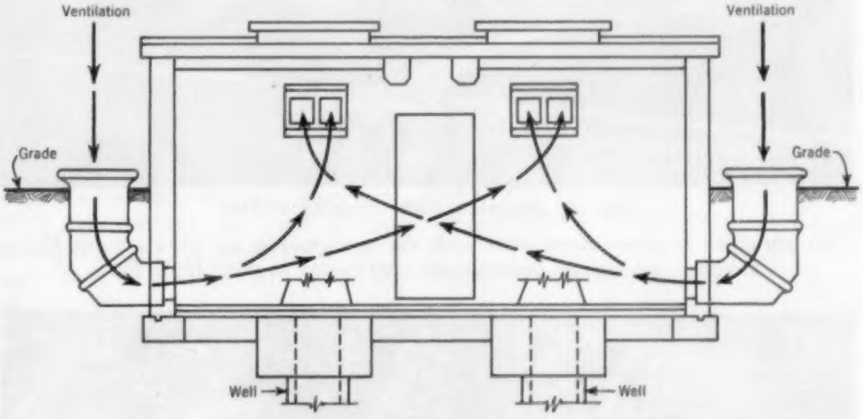


Fig. 4. Cross Section of Partly Underground Station

Adequate cross ventilation is provided by tile chimney vents and sash windows (see Fig. 3).

from the more attractive homes in the area.

Figure 2 shows the Floral Park Station about a year after it was completed. It is a low, white-painted, colonial style building with yellow shutters and trim. It houses two wells, three booster pumps, and lime-feeding equipment. Adjoining the building is an entirely underground storage tank. The top is painted green and surrounded by grass so that it is almost invisible from the roadway.

Since this first successful experiment in Floral Park, appearance has become a matter of prime importance in designing company installations. The aim is to build structures which harmonize with the style of nearby homes and represent a real asset to the community. As part of this "good-neighbor" policy, the company keeps its customers informed of building plans and makes every effort to gain their confidence and cooperation. Re-

Fig. 5. Bungalow Style Pumping Station

This attractive structure harmonizes with the residences in the area (North Valley Stream). A similar building was constructed in New Hyde Park.

Fig. 6. Ranch Style Pumping Station

This pleasing installation is located in Laurelton. The storage tank is visible in the left background.

cently, for example, the owner of a desirable site was reluctant to sell to the company because of possible objections from his neighbors. After he visited one of the new pumping stations and saw the completed structure and landscaping, however, he was sure there would be no problem.

Partly Underground Design

The use of residential type structures presented a number of design and engineering problems which required some ingenuity for their solution. For example, one of the most important considerations in planning a building for well pumps is providing for removal of the pumps and discharge columns when cleaning and repairs or well reconstruction are necessary. With the conventional type of flat-roofed building, a derrick 28–64 ft high could be mounted directly on top of the building walls or on beams spanning the walls. About 5 years ago a better way of handling this problem was devised. A pumping station for a semicommercial neighborhood was built with only its upper 3 ft above grade. Constructed of reinforced concrete, its visible portion is improved with stone facing (Fig. 3). Because the part of the building above grade is at the same height as the platform of a truck, pumping and other equipment can be rolled right from the truck to the roof. Another advantage is the confinement of operating noises. Although many pumping stations which are totally or partially underground are unsatisfactory because of inadequate ventilation, in this structure (Fig. 4) all the necessary cross ventilation was provided without mechanical equipment by installing tile chimney vents from grade to floor level in two walls and basement sash windows above grade in the opposite walls. This type of building has been used for one- and two-well installations in eleven semicommercial or older, low-cost residential areas.

The partly underground design was used, with some modification, to meet a problem in the Floral Park installation. In this case, the wells were placed in a structure entirely below grade with a hatch cover extending through the roof to a point 6 in. above grade. Thus, a repair derrick can be set on grade and the equipment removed through this opening. The hatch cover is located in the "backyard" of the house. The main portion of the Floral Park building aboveground houses the booster pumps, vacuum priming system, controls, and lime treatment equipment.

Other Residential Designs

After Floral Park, the company built two more stations of residential design (each with one well) in New Hyde Park and North Valley Stream (Fig. 5). Both are brick bungalows with colorful shutters and trim, similar to the homes in those communities. The main part of each bungalow houses the electrical control, pumping, and treatment equipment. The well pump is located in what appears to be an attached one-car garage. This part of the structure has a reinforced concrete roof slab to support a roof derrick. If a major repair were to require the use of a derrick 64 ft high, its legs would be able to span the width of the "garage" and rest on grade.

A more recent problem was the designing of a pumping station for a well and 1.6-mil gal storage tank with related booster equipment. The only

available site of sufficient size consisted of two lots with a combined frontage of 270 ft and a depth of 400 ft. Two houses already stood at the front of the property. The management wished to retain sufficient vacant land around each of the houses to resell them at a later date, thus recovering a substantial part of the cost of the entire parcel. The tank presented a major problem: its bottom had to be 2 ft above ground water elevation; it had to provide the required capacity; and it had to be as low as possible. The solution was to build a tank 120 ft in diameter with the top of the shell 2 ft above ground level. With the pumping station building itself, there was more latitude than in the past. Working with the well contractor, a plan was developed for a roof opening in the form of a chimney big enough to permit a crane to handle the equipment for repairs. This solution of the repair problem allowed considerable freedom in designing the building. A most pleasing ranch style brick house was selected (Fig. 6).

The company's most recent project consists of two wells, treatment equipment, a 2-mil gal ground storage tank, and booster equipment for the tank. Because the site of this installation is in an area where new development and redevelopment will take place in the near future, the management wished to make the building outstandingly attractive. A dignified, white-columned colonial structure was designed (Fig. 7). The municipal authorities who reviewed the plans for this building stated that if all utility companies showed equal consideration for the public, the usual opposition to utility development in residential areas would soon disappear.

Fig. 7. Colonial Style Installation

This picture is an architect's rendering of a suburban station nearing completion in Elmont.

An important result of the company's experience has been the realization that consumers are willing to pay more for better service and more at-

tractive facilities. The Jamaica Water Supply Co. applied for a rate increase on which public hearings were held early in 1954. This was after the 1953–54 expansion program had been fully publicized, the Floral Park building was well under way, and plans for other residential-type stations had been announced. Civic leaders at the hearing stated that they believed the company was entitled to a rate increase in view of the improved service and facilities being provided. When increased rates became effective, there was very little criticism from individual customers.

Executives of the company have also learned in recent years that there are many different ways to gain a desired end. Traditional ways are not, it seems, the only, or even the best, ways. Once a decision is made to break away from time-honored methods, ingenuity and imagination find solutions for problems which at first seem insoluble.

The management of the Jamaica Water Supply Co. believes that this new approach to utility construction in residential areas has made it possible for the company to grow and to meet its customers' needs realistically. Public response to the effort has been most gratifying.

California—Leslie A. Hosegood

A paper presented by Leslie A. Hosegood, Supt. & Chief Engr., Munic. Water Dept., San Bernardino, Calif.

Many problems have to be solved in successfully improving water service. The location and construction of suburban pumping stations often raise difficulties because of public reaction to the appearance of these facilities.

The AWWA public relations study published in the JOURNAL (*1*) brought to attention the public relations aspect of all water works activities. The public is directly concerned with the construction and operation of suburban pumping plants because they are normally located adjacent to or within a residential area. To insure the success of a public relations program, a water works must have the confidence of the people it serves. Building designs can be utilized which will in no way hinder present or future growth of a city. The residents of an area in which a station is installed will welcome an attractive structure. The surest way to gain the confidence of the public is to assure it that the utility has its interest at heart, and to make certain all activities support this claim. To accomplish this, the construction and development program must conform to the growth of a community's urban districts. Because it is possible that a city may develop around a plant, its design must permit it to blend into and become a part of the neighborhood. A water works has an obligation to consider the effect that the pattern of architecture will have on the appearance of the immediate area (*see* Fig. 1). The engineer's viewpoint is not the only factor, because there is more to be considered in the construction of an installation than mechanical operation.

Because the average citizen wants to be proud of his community, utility structures must remain pleasing for

many years. Reservoirs, pumping plants, and buildings to which he can point with pride, should be constructed. A handsome appearance does not necessarily entail excessive costs. On the other hand, an additional expenditure of money for plants that reflect credit to the community is a legitimate one. No matter how limited a budget may be, a necessary step in public relations is to provide attractive pumping plants.

Fig. 1. Unattractive Pumping Station
The appearance of this plant detracts from the neighborhood.

San Bernardino Plants

San Bernardino, like many other cities, obtains its supply from underground basins by the use of deep well turbine pumps. The location of the pumping plant is usually determined by one of three factors: the availability of the water supply, the economical location of each unit in relation to existing transmission lines, and the increased requirements of various areas to offset the addition of more and more subdivisions to already overloaded lines. The plants that San Bernardino and many other growing communities have located within residential areas can be constructed either aboveground or underground. Either type will provide good public relations if built properly. The structural features of such units are largely determined by local physical conditions.

Most of the water basins of Southern California are composed of water-bearing strata of sand, gravel, and boulders. The San Bernardino Basin, in particular, is very prolific, large quantities of water being produced from wells drilled in this area. Although varying amounts of sand are usually discharged from these wells when they are new, such problems are usually quite insignificant. In some wells, however, the difficulty is a major one. Many engineers, therefore, prefer to discharge the well supply into a settling tank, which not only provides a means of securing sand-free water, but also acts as an equalizer between the well supply and the booster pump discharge (*2*). This method of handling water has several advantages:

1. Maximum removal of sand from the water
2. Less stages required on vertical pumps with corresponding saving in replacements for bowls worn out by sand
3. More flexibility in a basin where ground water elevations vary and it is desirable to change the bowl assembly to meet new conditions
4. Provision for visual inspection of the water being discharged into the system.

Attractive Plants

Pumping and settling plants constructed in residential areas are designed to conform with the architectural motive predominant in those districts. This effect is accomplished through the erection of a building

which to all outside appearances is a house (Fig. 2). Ample landscaping of the grounds with shrubs and trees completes the concealment. In reality, such buildings are just clever shells to hide the well and pumping equipment. From the public's standpoint, they are ideal. Because they are designed to conform with the surrounding neighborhood, they blend into the general appearance of other houses and are unnoticed as pumping stations. Utility workers, striving for realism, are happy when handbill distributors leave pamphlets or free samples of merchandise at the door. During the construction of one plant, a woman actually inquired if the house was being constructed for rent or sale. The only noticeable oddity is that the pumping plants do not possess television aerials.

The main part of the house is a sand-settling and equalizing reservoir. In some instances, the well and turbine pump are located inside the building with the booster pumps. The pump is removed for repairs through a hatch in the roof. In later designs, the well has been placed in a "garage" at the rear of the plant (Fig. 3). The shell can be moved back to allow complete access to the well for maintenance. The electric controls and booster pumps are located within the main structure, in back of which are the transformers on a concrete pad, completely fenced and eventually landscaped by ivy or shrubs. Not one of these plants has had a dissatisfied neighbor.

Gaining Public Approval

The following steps are taken to insure good public relations: Before any work is started in the field, plans are submitted to the local planning commission. Upon receiving approval from that body, a representative from the water department calls on the residents in the district to acquaint them thoroughly with the proposed installation. The reason for choosing the particular site is explained fully because the public wishes to know why the plant has to be built in a developed area when there are so many unsettled districts within the city. This question can be satisfactorily answered if the public is acquainted with the problems of water distribution. A perspective drawing is made showing the appearance of the finished structure; pictures of this type are more easily understood by a layman than are detailed construction prints. Local residents are assured that the proposed station will not depreciate the value of their homes.

Value of Landscaping

Some cities in Southern California find conditions favorable to direct pumping into the distribution system, a procedure that is possible if the discharge from the deep well turbine pump is comparatively free of sand. If the water is carrying a comparatively small amount of sand, centrifugal type sand traps are used. The size of the sand extractor presents a difficult problem from the standpoint of architectural appearance. Landscaping of the grounds with shrubs and trees, however, can provide excellent concealment and eliminate complaints. In some installations, the sand extractor is placed underground.

The public relations problem is easily solved in new construction. Unfortunately, unsightly and isolated stations often become the center of a rapidly expanding residential area. In such instances, the plant must be structurally changed or the grounds sur-

Fig. 2. Pumping Stations for Today

Both of the structures were designed to harmonize with the type of architectural style used in their neighborhoods.

rounding the plant must be improved. Wonders can be accomplished through landscaping. Beautification of a plant is as much concerned with concealing ugliness as it is with augmenting attractiveness. The planting of greenery will make a fine screen behind which eyesores can be hidden.

Underground Installations

For the past several years, Southern California has been experiencing a phenomenal growth that has presented many water supply problems, such as lack of adequate supply and distribution facilities to serve the expanding area. As new sections are annexed to the city or water district, it is necessary to extend the distribution system. Such requirements present major difficulties because existing pipelines are not adequate. Additional booster stations or pumping plants must be built. The acquisition of suitable sites is not always easy.

Fig. 3. Camouflaged Well Housing

Although it seems to be a garage, this shell actually houses a well, which is located behind a plant resembling a house.

Lakewood Park, located near Long Beach, provides an ideal example of such expansion. There, 3,400 acres of new homes, schools, churches, parks, and shopping centers were created for 70,000 new residents. Inasmuch as a complete new water system was being developed, the plans included all suitable features. The pressure throughout the system is maintained by numerous pumping plants located throughout the city. They discharge directly into the mains. With the exception of surface storage reservoirs used for peak demand flows, all structures are located underground. As the plant site has an unobstructed surface, it can be utilized for parks or play areas.

Because of the lack of suitable vacant property or the high real estate values involved, it was deemed advisable in some locations to place the pumping plants in the sidewalk and street areas of the city. The only visible sign of such installations is the electric control panel in a weatherproof box on the sidewalk (Fig. 4). Access to pumping equipment and pressure tanks is through manholes, which do not interfere with automobile or pedestrian traffic. This method has received many favorable comments

Fig. 4. Electric Control Panel

The only visible sign that a pumping station is located underground is this weather-proof box.

from the residents of the area. All motor noises have been eliminated by the underground arrangement. System expansion is provided for by the purchasing of additional parcels of land for future plants. This property is now being utilized for recreation purposes.

Underground Plant Advantages

Locating a pumping plant underground will not limit the type of design. Lakewood and Fresno are examples of California cities which—because of the topography—utilize pressure tanks and direct pumping to maintain suitable pressures in the system (see Fig. 5). Pumping stations are located throughout the city for efficient operation. Water companies that have sand problems have had success with the underground placements of sand extractors or settling tanks. The Suburban Water Co. of Puente placed a large, twelve-cylinder, natural-gas engine and a deep well turbine pump producing 2,500 gpm in a pit. A simple float and mercury switch stops the engine if the installation becomes flooded. Burying plants and equipment below grade need not restrict their usefulness.

There are several other advantages of underground installation. For example, it is very effective for vertical pumping equipment for well pumps and close-coupled booster pumps (3). Because the head-capacity curve of a turbine pump is normally steeper than the curve of a horizontal booster, the pump will operate under a more constant capacity range with a resulting minimum of efficiency variation. Construction costs will be materially reduced by such placement. Investment in land can often be materially lessened or entirely eliminated.

In suburban pumping plants, motor noises are often a deciding factor in determining the type of construction. In structures resembling houses, liberal use of sound-proofing materials has considerably reduced noise. It is impossible to eliminate noise completely by sound-proofing large installations, as electric motors have a very high pitch. Because all sound can be completely eliminated in underground structures, they are becoming increasingly popular.

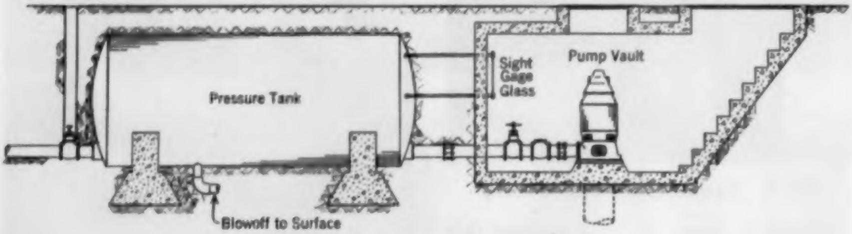


Fig. 5. Underground Pumping Plant

The type of design is not limited by an underground location. The only visible sign of this complex installation is the presence of three manhole covers.

From the public relations standpoint, suburban pumping plants should be of two general types: the under-

ground plant that is completely out of sight and occupies a minimum amount of space and the landscaped residential-appearing house that resembles the homes in the neighborhood. Either installation is acceptable to the residents of the area and is entirely satisfactory in the functioning of the water works.

References

1. Silent Service Is Not Enough!—AWWA Public Relations Study. *Jour. AWWA*, **46**:1187 (Dec. 1954).
2. Rossum, J. R. Control of Sand in Water Systems. *Jour. AWWA*, **46**:123 (Feb. 1954).
3. Fabrin, A. O. Vertical Short-coupled Turbine Pumps. *Jour. AWWA*, **45**: 1045 (Oct. 1953).

Pumping Station in Residence

The fine-looking colonial residence below is actually the Barrington Station of the Bristol County Water Co. of Rhode Island. This unattended installation provides aeration, filtration, and both low- and high-service pumping. All of the necessary equipment, including one of the supply wells, is housed in the building, which presents so pleasing an appearance that prospective homeowners have inquired whether it was for sale.

Water Supply for Greater Winnipeg

W. D. Hurst

A paper presented on Apr. 18, 1955, at the Canadian Section Meeting, Quebec, Que., by W. D. Hurst, Chairman of Comrs., Greater Winnipeg Water Dist., Winnipeg, Man.

THE Greater Winnipeg Water Dist., Man., was one of the pioneers in metropolitan water supply organization. The city of Winnipeg was first supplied by Assiniboine River water, which was pressure filtered and used from about 1882 to 1901 with very unsatisfactory results. The city then adopted a deep well supply which was continually expanded. In about 1912, however, it was realized that this supply could provide neither the quality nor the quantity of water needed to cope with the demands of a growing city.

From about 1908 on it was obvious that the city could not make the expenditure necessary to bring in an unlimited supply of soft water unless the entire area cooperated. In 1913, therefore, the Greater Winnipeg Water Dist. was created by the laws of the province of Manitoba.

Rights and Powers

The district was organized for the sole purpose of supplying water in bulk (that is, "not under pressure") to the cities of Winnipeg and St. Boniface, to two towns, and to five rural municipalities, all within the Greater Winnipeg area. The district has all the rights and liabilities of a corporation. It can acquire, hold, and alienate real property. It has perpetual succession, and it can sue or be sued. It was empowered to design, construct, purchase, improve, extend, maintain, and manage water works systems. It is entitled to build, manage, and maintain a railway and tramway system. It may acquire, lease, or purchase timber berths and leases, and it may also acquire and operate quarries or gravel pits. Under the enabling act, it has the power to add to its area by by-law at the request of a municipality.

The purpose of the district, of course, is to supply water from a permanent source, within or outside the province. It has actually secured water 97 miles east of Winnipeg, close to the Ontario border, from a lake in Manitoba that is connected with a series of lakes forming the Lake of the Woods system, all lying within the province of Ontario. It supplies water for the use of the inhabitants of Greater Winnipeg, who may use it for any and all purposes.

It will be apparent that the district has wide powers and functions, which are discharged by an administrative board consisting of the mayor and four elected representatives of Winnipeg, the mayor and one elected representative of St. Boniface, and the mayors of each of the other municipalities making up the district. The act re-

quires the mayor of Winnipeg to serve as chairman of the board. Ordinarily, all policies are decided by a simple majority, but any board member may require a vote to be taken according to municipal representation. In such cases, all the representatives of a municipality vote together. An additional vote is allowed for all property held, up to and including the first $5,000,000 of assessment, and another vote for every additional $5,000,000 of assessed property in the area.

This power of voting by municipal representation has not been used to date, but the section allowing for it still remains in the act. It was originally included to insure that Winnipeg would always hold a commanding voice in the corporation, because, at the time the district was formed, the city required 85 per cent of the water supply and was therefore responsible for 85 per cent of the cost. The junior municipalities, are protected, however, as any decision obtained by a municipal-representation vote may be appealed to the Manitoba Municipal and Public Utility Board, whose ruling is final.

Income and Expenses

The affairs of the district are managed by a board of commissioners of not more than three persons. This board employs a general manager, engineers, and other skilled personnel. The district is required to supply water "in bulk" through its main conduit to the several municipalities, which receive it at the nearest takeoff point. For this service, the district may charge up to 5 cents per 1,000 gal (Imp.). Because a very large sum of money had to be invested to bring the metropolitan scheme into operation, it is obvious that this rate is not intended to retire the debt. Its sole purpose is to pay the costs of maintenance and operation.

The debt is met by requiring each municipal corporation to impose levies based on an annual assessment of all taxable lands. The municipal corporation must collect a sufficient sum each year to provide for interest on the debt, plus a specific sum to be set aside either for a sinking fund to retire the debt or for a serial debenture retirement. Because different assessment methods are used by each city, town, or municipality, the Manitoba Municipal and Public Utility Board appoints a body every 3 years to make an equalized assessment of the entire district. It is on this assessment that the levy is based.

Expansion of Municipalities

When a municipality has a daily consumption of greater than 200,000 gal, the district is required to construct a supply line from the nearest point in the main conduit to the boundary of that municipality. The cost of this extension is borne equally by the district and the municipality. The district raises the money, and the municipality is required under law to meet 50 per cent of all debt charges and obligations on any such extension.

If a municipality desires to avoid construction costs, the act provides an alternative method of obtaining a similar result. Under this method, Winnipeg and St. Boniface are required to supply water not under pressure from their respective distribution systems to the system of the municipality requiring water. For the use of their mains, Winnipeg and St. Boniface receive from the district 5 cents per 1,000 gal of water delivered, the same rate that

the district charges for regular service.

Under the alternate system, the cities of Winnipeg and St. Boniface are only required by law to deliver water into a ground level reservoir at the municipality's boundary. In practice, however, the cities do supply water under pressure and make a charge for it, but such an arrangement concerns only the supplying cities and the municipality served. It is not a part of the district's responsibility. The act does require, however, that the permission of the district be obtained before a municipality served in this way can resell the water to other municipalities.

Conclusion

The Greater Winnipeg Water Dist., then, is a wholesaler of water brought into the area by a 97-mile-long gravity aqueduct having a capacity of 85 mgd (Imp.) from Shoal Lake, Man., which is an arm of the Lake of the Woods, lying mostly in Ontario. As the district is only responsible for delivering water in bulk to the several municipal boundaries, it might be said that the district is organized to move the Lake of the Woods into the Winnipeg area. It should also be mentioned that the diesel-powered standard railway which the district operates along the entire length of the aqueduct has been a principal factor in colonizing eastern Manitoba. This railway services the aqueduct and, fortunately, its cost of maintenance and operation is largely defrayed by receipts from the haulage of gravel from district-owned gravel pits 35 miles east of Winnipeg. With a present value estimated at more than \$60,000,000, the district has been a signal success since its inception.

Distribution of Water to the Suburban Areas of Halifax

J. D. Kline

A paper presented on Apr. 18, 1955, at the Canadian Section Meeting, Quebec, Que., by J. D. Kline, Asst. Mgr., Public Service Commission, Halifax, N.S.

HALIFAX, N.S., is on a peninsula. Dartmouth, the nearest incorporated town, is separated from the city by the mile-wide Halifax Harbor. It was natural that, as Dartmouth grew and became a town, it developed its own water system. On the other side of the peninsula from Halifax is the suburban area where governmental authority is exercised by the Municipality of the County of Halifax. Here, residential development has moved slowly. In recent years, however, the health hazards of housing concentration without proper facilities have become increasingly serious.

The Halifax water system was started in 1844. This first system, with its early improvements and enlargements, was partially financed through general taxation of the citizens.

Up to the beginning of World War II and probably for some years after, there was not sufficient concentration of housing in the suburban areas to warrant an extension policy for the Halifax water system. There were occasional requests for water service from this area, but the city council did not feel inclined to subsidize any suburban extensions, as the original system had received some benefits from city taxes. At that time there was also a general expansion in the city and all available capital funds were required for extensions of the various municipal services within the city itself.

Need for Service

The Halifax system is supplied from lakes located outside the suburban areas, with transmission lines running through these areas to the city. In sections adjacent to the water transmission lines, permission was granted by the Halifax city council, through the Works Dept., which then operated the water system, to allow subdividers to connect their own distribution systems to these mains, with no expense being borne by the city. Actually, these were 2-in. lines or smaller, installed with individual smaller services laid to the various houses. Meters were sold to the individuals and bills rendered on the measured consumption. Owing to poor installation and maintenance, the small distribution lines eventually leaked badly and meters became inoperative, with a consequent loss in revenue to the city.

As the area grew, more houses were connected to these small-diameter extensions and service became inadequate. Eventually, as the original subdivider passed out of the picture, it was the individual homeowners who were faced with the problem. This

was the city's only experience in suburban water service, and it certainly did not show a profit.

Just prior to 1944 there was considerable discussion on forming a metropolitan commission to administer and operate various utilities and services in Halifax, Dartmouth, and the surrounding areas of the county. The various political councils were not too enthusiastic, however, and plans for such a commission were relegated to the background.

Public Service Commission

This, then, was the situation in 1944 when the Halifax Public Service Commission was formed to operate the water system. During the first few years, complete attention was centered on reorganizing the system and carrying out a heavy maintenance program. At this time urgent requests for extensions were being made by the suburban areas, because of a definite health hazard resulting from increased development and lack of proper water and sewage facilities.

The commission's first contact with suburban service was under its general rehabilitation program. Master meters were installed at the transmission mains on the small distribution systems already referred to, the individual meters were purchased and repaired, and all water measured at the master meters was included in the water bills, regardless of whether it was consumption or waste.

Under the Act of Incorporation, the commission had the necessary authority to "engage in any public utility business in any part of the county of Halifax," subject to compliance with the regulations of the Board of Commissioners of Public Utilities, a provincial government regulatory board. The commission had the necessary capacity and plant to handle an increased consumption, and the planned development of large mains near the city limits allowed for the extension of proper trunk mains into suburban areas at a reasonable cost.

Realizing the legality, feasibility, and desirability of extending water service into the suburban areas, the commission was willing to negotiate with the county and an agreement was signed in June 1951 setting down the principles for suburban extensions.

Costs and Rates

Briefly, any extension under this agreement must be requested by the county and approved by the commission and utility board. The extension is installed by the commission, which pays the capital costs, and becomes part of its system for operation and maintenance. An annual return to the commission of 12 per cent of all capital invested is required. This figure covers:

1. *Interest on debt*—4½ per cent (based on an estimate of interest requirement on a bond issue; this rate is being paid by the commission on its latest issue)

2. *Serial retirements*—2 per cent (approximately equal to the requirements on present 30-year bonds)

3. *Depreciation*—1¼ per cent (plant consists mostly of 6-in. mains having a 75-year life and a 1.33 per cent depreciation rate, together with some 8-in. mains, having a 100-year life and a 1 per cent depreciation rate)

4. *Operation and Maintenance*—2½ per cent

5. *Profit on investment and provision for contingencies*—1¾ per cent (such as fluctuations in loan costs or operating expenses).

The revenue to provide this 12 per cent return comes from quantity charges to all users and fire protection charges to the county. Any deficit must be guaranteed by the county.

To date, this agreement covers only extensions that can be served by the gravity system and that require no extra pumping installations. The commission realizes, however, that pumping plants will be needed in the near future for further extensions and has planned a broad outline for the required system. This second stage will, of course, require a greater capital investment per customer by the commission and will therefore necessitate higher rates. In preference to zone rates, the commission favors customer participation by capital contribution, thus lowering the original cost and maintaining a uniform charge. This theory has not been fully developed and would, of course, require the cooperation of the various consumers and land subdividers in the suburban areas.

Before requesting an extension, the county authorities require that at least 60 per cent of the lot owners agree to become water consumers. At the beginning of this program, temporary rates were established with the approval of the utility board. These rates were based on the number of committed consumers and were estimated to return the regulated 12 per cent. At that time (1951–53) the county did not have the necessary legislative authority to tax for fire protection, and an average amount was included in the minimum bill to each customer to cover such payment.

In 1954, when the gravity system was completed, costs were reviewed and final rates approved by the utility board. As the county had obtained the necessary authority to levy a fire protection tax, this charge was omitted from the commission's bills.

The minimum annual bill for domestic customers in the suburban area is \$36, plus \$0.25 for every 1,000 gal of water used. In the city, the minimum annual bill is \$18, but 7,000 gal is allowed per quarter, with all additional consumption being at the rate of \$0.25 per 1,000 gal. It can be seen that the suburban rate is more than double the city rate.

The fire protection charge invoiced to the county is patterned on a formula used for levying a similar charge to the city of Halifax. This formula was designed for Halifax in 1947, after a very exhaustive study to determine the proper allocation of the portion of capital plant and annual maintenance and operation expenses necessary for fire protection. The annual charge to the county may be expressed by a rule-of-thumb formula as 2½ per cent of the capital invested in the water system in the suburban area. This amounted to \$3,845 for 1954, equivalent to a rental of \$167 per hydrant per year. This charge, approved by the utility board, is paid directly to the commission and reclaimed by the county through taxation.

The invested capital, on which the 12 per cent return is calculated, includes the cost of all distribution mains within the area, a portion of the cost of a large trunk main laid on a city street adjacent to the city-county boundary and from which the county distribution system receives its supply, the installed cost of all consumers' meters, and an allowance of 5 per cent on capital expended for engineering and overhead. No cost is included for individual services nor for any of the primary plant, such as dams and treatment works.

It is believed that the present suburban extension policy is sound. It provides for ownership and thus insures the commission's complete control, from original design to final maintenance, operation, and administration. The financial arrangements provide a self-supporting system with no hardship on the primary service area. Because available land within the peninsula is now scarce, Halifax cannot expect a greatly increased future expansion which might require heavy additional water demands. It is good business, therefore, to sell surplus water to the suburban areas.

Conclusion

To some extent, Halifax' extension plans have been affected by certain disadvantages in the suburban expansion program. Town planning regulations governing suburban development, for instance, were not adequate until recent years. The poor building codes, inadequate sanitary facilities, and unplanned streets and roads which resulted are difficult and expensive to change now. Water main extensions are an added burden on a totally inadequate sewer system which would require very heavy expenditures to modernize.

As the commission operates the water utility only, this problem does not concern it as directly as it does the city of Halifax and the county, the two bodies which operate the sewer systems in their respective areas. The sewer problem within the metropolitan district has again raised the question of a metropolitan commission. In 1954 the provincial government added its support and is cooperating with the city, the town of Dartmouth, and the county in a survey of the requirements for adequate water and sewer service throughout the entire area. It is quite possible that these studies will lead to the formation of a metropolitan commission with authority over the entire district. Such a step would probably necessitate changes in commission policies on suburban extensions.

Report on Loss in Carrying Capacity of Water Mains

T. E. Larson

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by T. E. Larson, Head, Chemistry Subdiv., State Water Survey, Urbana, Ill. This report was prepared for AWWA Committee 2810 D--Effect of Purification Methods on Water Main Carrying Capacities, whose function is to advise, assist, and supplement the study being conducted on this subject by the Illinois Water Survey.

THE loss of main carrying capacity through corrosion and precipitation is a very serious problem. The replacement value of municipal distribution systems in the United States is estimated at approximately ten billion dollars. In many systems the carrying capacity has been reduced by more than 50 per cent. As the majority of mains in service are coal tar–coated cast iron, the present study is primarily concerned with this type. The investigation has been further limited, though only temporarily, to the mains of municipalities using Great Lakes waters, because: first, such untreated water is generally considered to be relatively noncorrosive; second, many cities use such water; and, third, unpublished reports and other data indicate an appreciable variety in the carrying-capacity losses experienced at various cities.

Because loss in carrying capacity is associated with the "roughness" of the interior of the pipe, it is important to define the different types of roughness that may develop:

1. The slime deposit or growth of bacteria, whether or not manganese or iron is present, generally occurs over the entire main surface. This condition is not known to exist when raw or treated Great Lakes waters are used.

2. Deposition of silt from untreated water is not uncommon in old mains or those operating under conditions of low flow. Such depositions are known to be present even where water clarification has been practiced for over 20 years. In addition to sand, samples have been found to contain aluminosilicate clays and microorganisms. The effect of these deposits on carrying capacity is probably only slightly greater than calculations from the reduction of the pipe cross section would indicate.

3. Incrustation, or the formation of a crust over the metal surface, may be of various kinds, such as: [a] tuberculation in the form of nodules or spicules, resulting from localized corrosion; or [b] afterprecipitation or uniform deposition (not always a hard crust) of insoluble products on the pipe wall.

Unpublished information and firsthand observations have shown that crustation may exist simultaneously or separately in a specific pipeline. Also, tuberculation and afterprecipitation may exist together or separately. This study is concerned almost exclusively with incrustation, primarily with

the tuberculation resulting from corrosion. Methods for control of after-precipitation of insoluble products are generally well established, although not necessarily applied.

The first major problem which confronted the present investigation was that of evaluating and developing "tools" or criteria for measurement not only in laboratory and field studies of corrosion and tuberculation, but also in the study of pipe roughness resulting from tuberculation and other causes.

Measurement of Roughness

Current methods of determining flow capacity usually involve measuring the velocity and head loss. Another procedure accurately determines the velocity factor (average velocity divided by the velocity at center) alone, without a head loss measurement, and interprets it in terms of flow capacity (a high factor indicates good capacity, and a low factor poor capacity). The head loss and velocity data, as well as accurate velocity factor data, can be indirectly related to roughness. An important consideration for this study is evaluating the extent to which capacity determinations will indicate the physical thickness of roughness and be comparable for different pipe diameters.

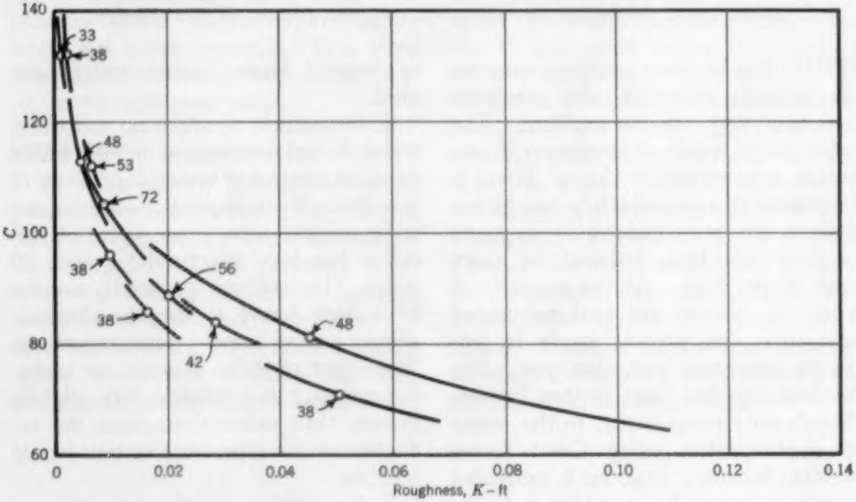


Fig. 1. Relation of Head Loss Accuracy to Roughness Calculation

The figures on the curves indicate the age of pipes in years. Thus, for a 48-yr-old, 30-in. pipe with a 1.20-ft head loss in 2,810 ft at a velocity of 1.2 fps, C *is 81 and* K *is 0.045 ft. For the same pipe, at 1.70-ft head loss,* C *is 65 and* K *is 0.11 ft. At 0.70-ft head loss,* C *is 96,* K *is 0.017 ft.*

The velocity of flow through a pipe under a measured head loss can be accurately determined within the limits of observational error, specifically at the conditions of the test. A "capacity coefficient," such as the well known Hazen-Williams C, can be calculated to depict the carrying capacity for pipe of the same size under similar condi-

tions. The coefficient, however, is not a direct indication of roughness. The same measured data can also be substituted in the Darcy equation for the friction factor (f) and then in the lesser known Colebrook-White equation (*1*) to provide a calculated or "effective" roughness height (K), or a "roughness coefficient":

$$\frac{1}{\sqrt{f}} = 1.74 - 2 \log \left(\frac{18.7}{\mathbf{R}\sqrt{f}} \right) + \frac{K}{r}$$

in which f is the friction factor; $\mathbf{R}$ is the Reynolds number; r is the radius; and K is the effective height of roughness, equivalent to sand grains of diameter K expressed by the above equation.

The relationship expressed by the above equation is considered basic in modern fluid mechanics and has been stressed rather strongly at recent meetings of the International Water Supply Congress (*2, 3*). The roughness coefficient is comparable for similar roughness in pipes of different sizes and should serve as a possible comparable unit for measurement of incrustation.

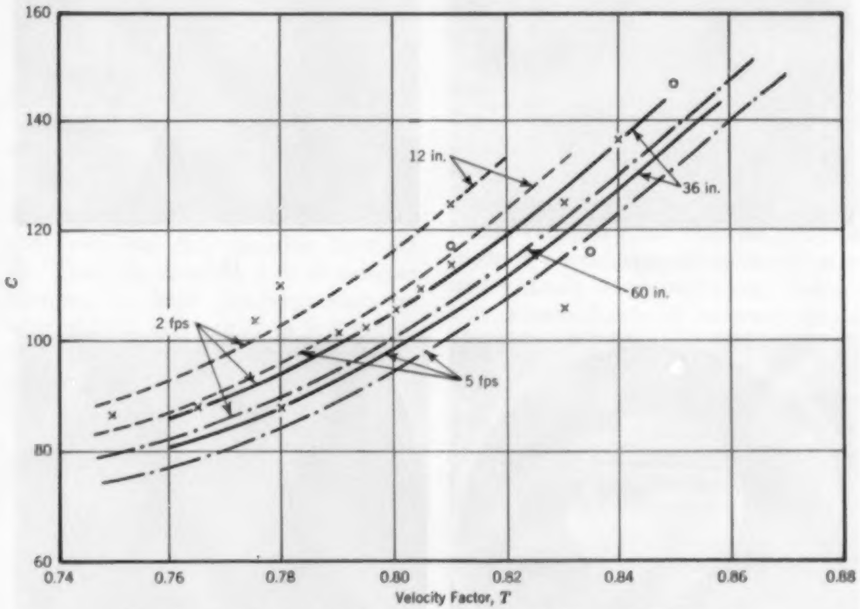
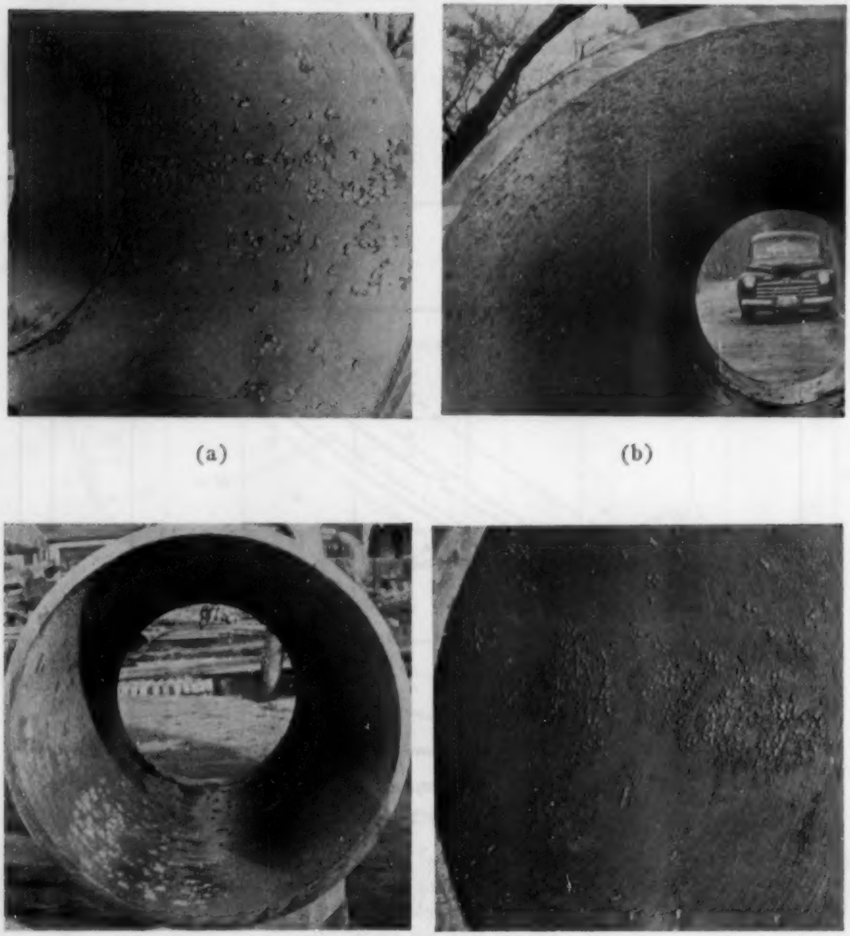


Fig. 2. Correlation of Velocity Factor and Hazen-Williams *C*

The velocity factor coefficient is the ratio of average velocity to maximum velocity at the center. The symbol × indicates coated cast iron pipe; the symbol ○, concrete. All points represent data from reported field tests on 36-in. pipe. Ranges indicated for all pipe are empirical.



(a) (b)

(c) (d)

Fig. 3. Conditions of Tuberculation and Afterprecipitation

These deposits resulted from 21 months of operation by coagulation and settling. The velocity factors are as follows: (a) 48-in. diameter, average T = *0.803* (C = *102* ±), K = *0.0100 ft; (b) 48-in. diameter, average* T = *0.785* (C = *94* ±), K = *0.0180 ft; (c) 24-in. diameter, average* T = *0.754* (C = *84* ±), K = *0.0240 ft; (d) 48-in. diameter, average* T = *0.755* (C = *81* ±), K = *0.0480 ft. All pipes were removed from within ¼ mile of traverse location.*

For a comparable calculated or effective roughness of 0.03 ft, C (Hazen-Williams) would be 74 for a 12-in. pipe and 86 for a 48-in. pipe. For a comparable C of 86, K would be 0.015 ft in a 12-in. pipe and 0.03 ft in a 48-in. pipe. Similar comparisons can be made for smooth pipe. Thus, for an equivalent C, the depth of roughness in a 48-in. pipe is calculated to be approximately twice that in a 12-in. pipe.

Accuracy

In the determination of C, it is frequently reported that the accuracy of the head loss determination is ± 0.5 ft. Thus, for example, a $\pm$ 10 per cent accuracy in head loss represents an approximate error in C of 5 per cent for a 36-in. pipe at 3 fps, corresponding to the following:

C

130 (from 123.5 to 136.5)
80 (from 76 to 84)

K (ft)

0.0014 (from 0.0008 to 0.0021)
0.0380 (from 0.030 to 0.052)

In a randomly selected series of tests at one municipality, such error could amount to as much as 2–20 per cent of C for the eleven mains involved. It will be noted in Fig. 1 that the absolute error is large for C and low for K in clean pipes. In rough pipes, however, a small error in head loss corresponds to a large error in the roughness calculation. Other variables of more or less significant proportion lie in the measurement of velocity ($\pm$ 1 per cent of C), the neglect of viscosity ($\pm$ 2 per cent of C, from 60°F), and the sometimes unknown loss of water (takeoffs) between the points of measurement of head loss.

Velocity Factor

The other procedure used for estimating the carrying capacity and the roughness consists of a careful measurement of the velocity factor. Although this is an approximate determination, it correlates surprisingly well with the Hazen-Williams C. Figure 2, based on carefully determined velocity traverses, shows this correlation. The degree of care exercised in the determination of this parameter affects its validity. Obviously the velocity traverse is not valid if it is not symmetrical about the centerline. To insure symmetry, the traverse must be made on a long, straight section of pipe under steady flow conditions. Preferably, a second velocity traverse should be made at a 90-deg angle from the first. Precaution should also be taken to insure that all primary readings are made at a specific velocity. The usefulness of this parameter, of course, requires that the section of pipe upstream (which has been responsible for the velocity pattern) is representative of the type and quantity of roughness throughout the entire pipe under test. That this is not always true is shown in Fig. 3C.

With refinement in technique and in mathematical analysis this method may prove to be more valuable for calculating pipe roughness. It is beyond the scope of the present study to pursue this question further, however.

The most serious criticism of the C value of Hazen-Williams, the K of Colebrook, and the pipe traverse procedure, lies in the fact that even if they are highly accurate, they do not distinguish between the types of roughness, such as tuberculation and afterprecipitation, or sedimentation and slime.

The series of photographs in Fig. 3 represents conditions of tuberculation and afterprecipitation in mains having velocity factors of 0.803–0.754. These pipes all show a rippled deposit of silica and alumina as well as tuberculation. The deposit resulted from 21 months of operation by coagulation and settling, but without filtration. Two other locations have provided data indicating no pipe with K greater than 0.01 ft, using untreated Great Lakes water.

Figure 4 represents calculations of roughness heights determined from data on velocity factor. This type of data was the only data available in a substantial quantity, and the relative roughness height was calculated from the empirical relationship shown in Fig. 2. It can be interpreted only to mean that a change took place after the treatment plant was installed. Fig. 4 is associated with the photographs in Fig. 3.

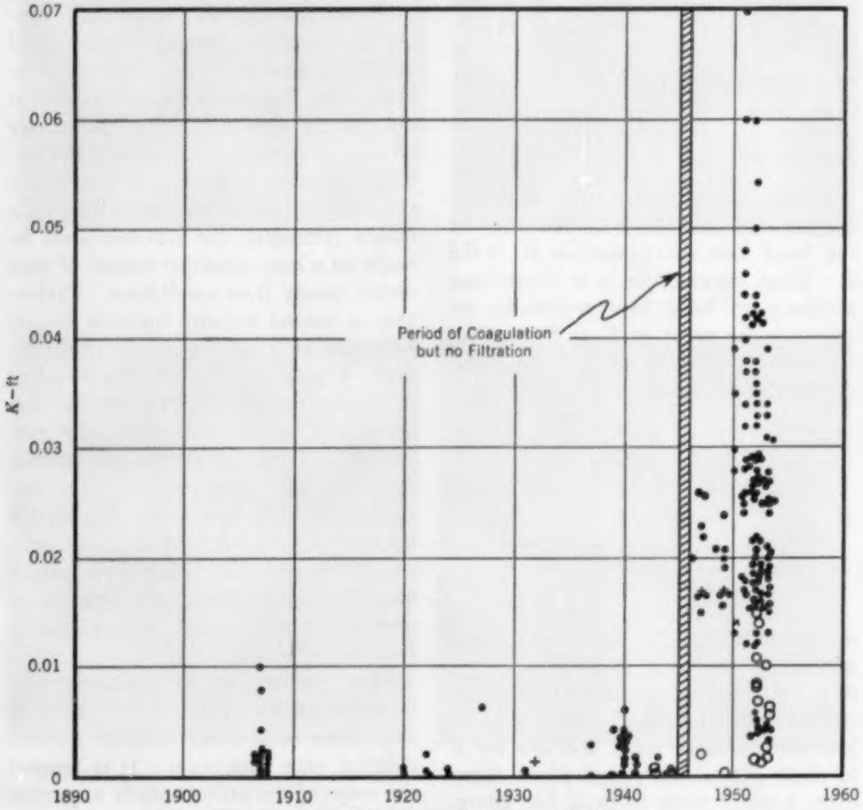


Fig. 4. Calculations of Roughness Height

These roughness determinations were calculated from velocity factor T.

From the preceding figures and discussion it appears improbable that a precise understanding of the type or quantity of roughness can be obtained from the capacity tests in present use.

They are not designed specifically to indicate such small degrees of tuberculation as might have developed during a relatively short period of change in chemical treatment. Very low values of C, as usually determined, indicate only roughness of major proportions. There is, therefore, no completely satisfactory criterion for the physical condition of the pipe interior. This is not a criticism of flow tests when carefully made to determine carrying capacity, however, but an evaluation to indicate a limitation on the extent to which such tests can be used, even comparatively, to determine a change in pipe roughness, specifically tuberculation.

Tuberculation

Because tuberculation results from corrosion, the problem demands that a field "tool" be developed to indicate the corrosive potential of water—not to determine roughness, but to determine corrosivity as distinct from sediment or deposition. This tool must be usable at any place in the distribution system and under any condition of flow. It must be sensitive to the effect of supersaturation with calcium carbonate as a corrosion inhibitor (not as an incrustant) and to other inhibitors that may be present. It must also be sensitive to the effect of the possible corrosives which may be present, such as dissolved oxygen, or low pH.

The development of such an indicator would help to solve the current problem, and it is toward this objective that much of the laboratory testing is being directed. At present, a method involving measurement of potential changes induced by applied current densities of a few microamperes per square decimeter seems to offer the best hope. Results from this method show increasing promise, but they are not sufficiently conclusive to warrant detailed discussion at this time. It is possible, too, that the method may have limited application.

It has been frequently—almost persistently—suggested that experimental pipelines be tested at one or more water plants and observed with treated waters of various chemical qualities. The objective of this procedure has merit, but cost and time are practical considerations that cannot be overlooked, particularly when it is realized that literally dozens of modifications in treatment would require evaluation. It is estimated that, if five parallel lines of 4–8-in. pipe were installed for this purpose, the cost of appropriate valves, orifices, and chemical-feeding equipment would be more than $10,000, even if a constant-head supply of 0.5 mgd were available. Furthermore, such tests may require months or years to assure reliability of observations unless a satisfactory tool is developed.

Field Studies

Field visits to a number of plants have disclosed several significant differences in the quality of treated water. In general, one group provides water of pH 7.3–7.5 and another group, pH 7.9–8.2. The former makes no attempt to maintain calcium carbonate saturation. Some plants in the second group maintain a relatively constant pH with no regard to the temperature effect on $CaCO_3$ solubility. If this means of stability is to be used, it should be recognized that the saturation pH (as determined at the temperature of the effluent) varies from about 7.95 at 77°F to 8.45 at 32°F.

As for effluents of pH 7.3–7.5, oral reports indicate little or no loss in carrying capacity in some cases, but this was without flow test data. One plant reports severe losses in many

mains, as indicated in part by flow tests. In this case, however, the data are complicated by the known presence of afterprecipitation and old silt depositions prior to coagulation and filtration. Examination of pipes revealed frequent tuberculation.

Another plant frequently produced an effluent of pH 6.8–7.0. Flow tests indicated a *C* coefficient of 93 (*K* = 0.013 ft) in a new 24-in. main from the plant after 4 years of use.

Several plants used marginal chlorination (less than 0.1 ppm NH_2Cl); one used chlorine dioxide; one carried free and combined chlorine; and another had carried free chlorine for a period of about 8 years. Other alterations in treatment during this period and the insensitivity of flow test data precluded field evaluation of this factor.

Wide variations in sampling and analytical procedures preclude any evaluation of silica and alumina residuals in the treated effluents. Further study of the solubility of alumina and silica at various temperatures, as influenced by pH and other mineral variations, would be valuable.

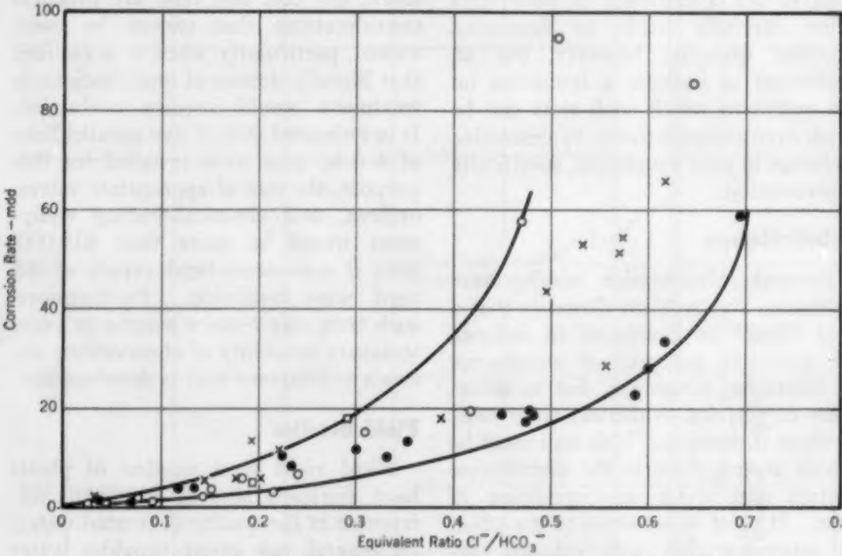


Fig. 5. Effect of Cl^-/HCO_3^- Ratio on Corrosion of Mild Steel

Alkalinity (as $CaCO_3$) is shown as follows:
●— 75–100 ppm, ○—150–180 ppm,
×—120–135 ppm, □—250–260 ppm.
The abbreviation "mdd" stands for milligrams per square decimeter per day.

Samples of incrustation received from several plants are being analyzed to determine their compositions.

Laboratory Studies

Jar tests are being conducted in the manner described by Larson and King (*4*) using steel and cast-iron specimens.

After considerable time had been spent in evaluating various methods of preparing specimens, it was found that very minor stresses imposed on the steel by lack of care in handling promoted excessive variability in results. Subsequent testing accompanied by potential measurements established a corrosive-inhibitive relationship for various equivalent ratios of chloride-bicarbonate salts of sodium at pH 7, as shown in Fig. 5.

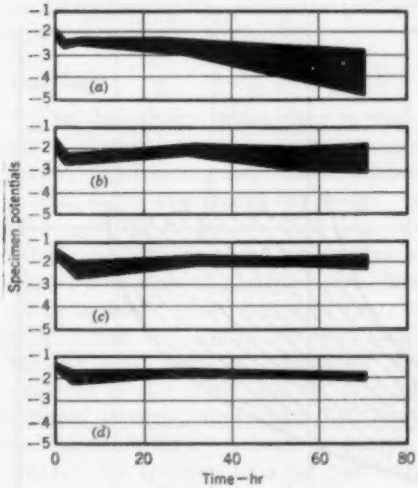


Fig. 6. Potential-Time Data at Four Levels of Cl^-/HCO_3^-.

Increasingly high rates of corrosion occur as the chloride-bicarbonate ratio increases. Range of Cl^-/HCO_3^- ratio: (a) 0.57–0.63; (b) 0.29–0.36; (c) 0.18–0.21; (d) 0.06–0.10. Specimen potentials are in volts versus saturated calomel electrode.

This figure would appear to indicate that even small proportions of chloride to alkalinity cause some corrosion. Potential-time data show, however, that under these conditions corrosion appears to be somewhat high on initial immersion but becomes at least partially inhibited with time. The potential-time data at four levels of Cl^-/HCO_3^- are shown in Fig. 6. This is a qualitative, not a quantitative, measure of corrosion rates. From these data it appears that increasingly high rates of corrosion occur as the chloride to bicarbonate ratio increases, particularly above a value of 0.3. This proportion approximates the proportion of chloride plus sulfate to bicarbonate in Great Lakes waters and classifies (*4*) such water in a range which is sensitive to additional corrosives and probably inhibitors.

C. H. Spaulding, in a preliminary unpublished study of this problem, suggested that free chlorine appeared to be responsible for excessive tuberculation. This and other work on the problem (*5*) prompted the undertaking of a number of tests to obtain a relative evaluation of this factor. These tests indicate (Fig. 7) that free chlorine in concentrations above 0.4 ppm corrodes steel at room temperature in aerated water of about 120 ppm

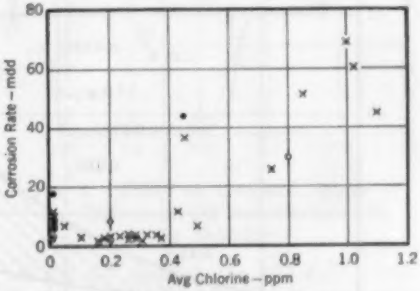


Fig. 7. Effect of Free Chlorine on Corrosion of Mild Steel

The alkalinity (as $CaCO_3$) was 120–135 ppm. The chloride-bicarbonate ratio was 0.18–0.27. The running time of the test is indicated by × = 3–4 days, ○ = 10–20 days. The pH was 7 in all cases except where ● = indicates a pH of 8.

alkalinity and 30 ppm sodium chloride, pH 7 and 8, at low velocities. In Fig. 8, these results have been superimposed on the previous Fig. 5 to indicate the relative corrosion rates at the particular chloride-bicarbonate ratio. Figure 8 also shows the results of tests of 3–6 days' duration using chloramine in concentrations of 0.4–3.6 ppm. These data appear to indicate that corrosion is somewhat inhibited by this means. rather than 30 ppm, the additional corrosion induced by 0.4–1.0 ppm chlorine may have been negligible. No additional studies have been made on other corrosives or inhibitors.

Tests have also indicated corrosion rates to be higher at pH 8.5 and 9.0 than at 7.0, 7.5, and 8.0. A twofold increase in corrosion rate resulted when the velocity was increased from 0.14 to 0.89 fps at pH 8.5 and 9.0 with

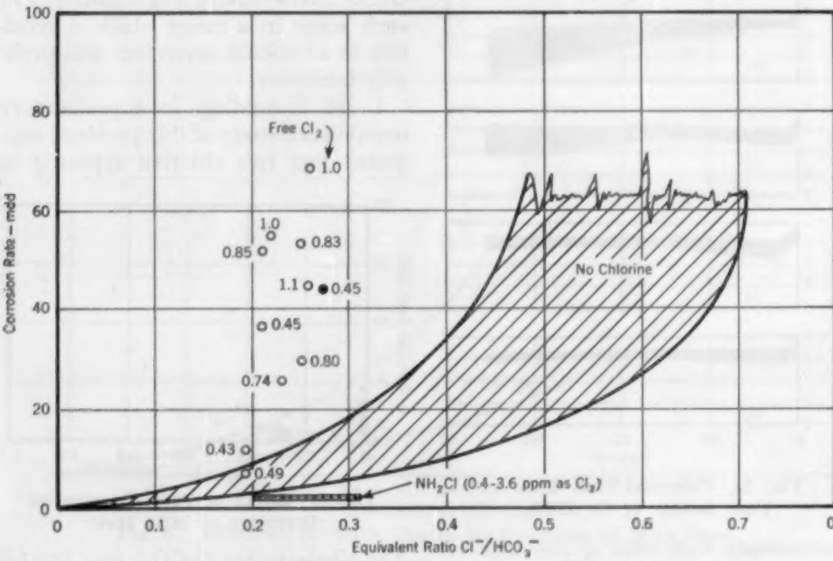


Fig. 8. Relative Corrosion Rates at Particular Chloride-Bicarbonate Ratios.

Effects of free chlorine as shown in Fig. 7 have been superimposed on Fig. 5 to show the relative corrosion rates.

It is probable that similar relative results would *not* have been obtained at other proportions of chloride to bicarbonate. If 5 ppm sodium chloride had been used rather than 30 ppm, a greater proportion of inhibitor would have been present and more than 0.4 ppm chlorine may have been necessary for comparable corrosion rates. If 80 ppm sodium chloride had been used 1,000 ppm alkalinity and 120 ppm sodium chloride. This is shown in Fig. 9. Minimum corrosion was noted at pH 7.0, 7.5, and 8.0 at both rates. As high pH is normally considered an inhibitor, the data on this character of water are reported to indicate what may be considered as lack of a basic standard of corrosivity. It is only from basic information on the correla-

tive influence of the primary corrosive ion (Cl^-) and inhibitive ion (HCO_3^-) that reasonable and consistent progress can be made. These jar tests are somewhat crude, but the general trends of the influence of variables are certain. The border line influence of minor variations of these and other variables will require even more accurate techniques than are now available. As mentioned previously, efforts are being made to develop the necessary tool for this purpose.

Coatings

The desirability of coatings is obvious. Without them, in an aggressive water, corrosion and tuberculation would occur even more seriously. It is reasonable to believe that less inhibitor will be required to protect a coated pipe than an uncoated pipe, just as in cathodic protection less current is required for coated surfaces than for uncoated surfaces. Limiting the problem to the usual coal-tar type of internal coating, very little has been published on its application or composition. No specifications for cast-iron pipe coal-tar coatings are in effect, for reasons beyond the scope of this discussion.

It is of course the aim of every manufacturer to produce a passable coating that will meet competition. As is true for any item manufactured without suitable standards or specifications, differences should be expected to exist even in the coating of a single producer. It is therefore not surprising to note that in a single shipment of pipe some will show the effects of weathering, while others will not. There will be flaws in some and not in others. Some will resist an aggressive water over a period of years, some will not.

There is no coating, lining, plating, or paint job that is absolutely infallible, but it is probable that both sprayed and dipped coatings can be improved by standardization. The producers of tar coatings and the pipe manufacturers might also evaluate the possibility of impregnating the coating with an appropriate inhibitor for the benefit of the industry. Again, the extent of the

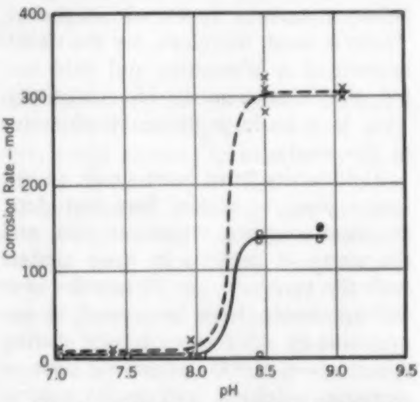


Fig. 9. Effect on Corrosion Rates of Increased pH and Change in Velocity

At pH 8.5 and 9.0, the 0.14–0.89-fps increase in velocity doubles the corrosion rate. In these tests, conditions were as follows: × indicates a velocity of 0.89 fps, a chloride-bicarbonate ratio of 0.16, and an alkalinity of 700; ○ indicates a velocity of 0.14 fps, a chloride-bicarbonate ratio of 0.10, and an alkalinity of 1,050.

effectiveness of such an inhibitor will depend on the degree of aggressiveness of the water as well as the overall quality of the coating.

Summary

A bibliography has been prepared on the subject of carrying capacity. It covers approximately 160 papers by about 260 authors.

Study of loss in carrying capacity is being limited to tar-coated cast-iron mains, specifically those in the Great Lakes region. Primary, but not sole, concern of the investigation is the losses due to tuberculation.

The head loss–velocity test for capacity has been evaluated and found inadequate for use as a critical indicator of roughness, specifically by tuberculation. It does not distinguish between various types of roughness. There is need, therefore, for the development of a laboratory and field tool for the measurement of corrosivity. This is a basic preliminary objective of this study.

Field visits have been made to examine pipe, to obtain flow test data, chemical analyses, treatment data, and the views of persons in close contact with the problem. In 10 months over 500 specimens have been used in approximately 45 series of tests during which about 9,000 operations such as cleaning, weighing, and quality control testing, have been carried out. Over 16,000 current and voltage readings have accompanied these tests.

Through careful laboratory tests, free chlorine has been found to be corrosive to steel at concentrations above 0.4 ppm, at low velocity, at room temperature, in water of 30 ppm NaCl and 120 ppm alkalinity at pH 7. Under these conditions chloramine in concentrations up to 3.6 ppm was not found to be significantly corrosive.

Tar coatings are desirable and may be improved.

Acknowledgments

This survey is supported by Research Grant G4007(R) from the National Institutes of Health, US Public Health Service. Because adequate personnel have not been available, only about half of the first-year funds has been spent. A 6-month extension has been requested and received without prejudice to subsequent appropriations. Substantial support is also derived from the Illinois State Water Survey.

Grateful acknowledgment is also made to the many water works personnel who have cooperated wholeheartedly toward the preparation of this preliminary and summary report. The many helpful discussions with members of the AWWA advisory committee and others have been highly valuable in orienting and outlining the existing problem.

Particular acknowledgement is due A. M. Buswell, whose active interest as chairman of the AWWA advisory committee and as supervisor of Research Grant G4007(R) contributed invaluable guidance.

References

1. Colebrook, C. F. & White, C. M. The Reduction of Carrying Capacity of Pipe With Age. *J. Inst. Civ. Engrs.* (Br.), **7**:99 (1937).
2. Lamont, P. A. The Reduction With Age of the Carrying Capacity of Pipelines. *J. Inst. Wtr. Engrs.* (Br.), **8**:53 (1954).
3. Lamont, P. A. A Review of Pipe Friction Data and Formulae With a Proposed Set of Exponential Formulae Based on the Theory of Roughness. *Proc. Inst. of Civ. Engrs.*, p. 248 (1948).
4. Larson, T. E. & King, R. M. Corrosion by Water at Low Flow Velocity. *Jour. AWWA,* **46**:1 (Jan. 1954).
5. Williams, D. B. Dechlorination Linked to Corrosion in Water Distribution Systems. *Wtr. & Sew. Wks.*, **100**:3 (Mar. 1953).

US Public Health Service Research Grants

Irving Gerring

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by Irving Gerring, Exec. Secy., San. Eng. & Occupational Health Study Sec., Div. of Research Grants, National Insts. of Health, US Public Health Service, Bethesda, Md.

THE US Public Health Service research grants program is directly related to the field of sanitary engineering or environmental health, which includes water supply control.

The Div. of Research Grants of the National Institutes of Health was established late in 1945 and was made responsible for the administration of all research grants and fellowships programs by Public Law 410, the Public Health Service Act, which was passed in 1944. Sec. 301 states in part:

> The Surgeon General shall conduct the Public Health Service, and encourage, cooperate with, and render assistance to other appropriate public health authorities, scientific institutions, and scientists in the conduct of research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of the physical and mental diseases and impairments of man, including studies of water purification, sewage treatment, and the pollution of lakes and streams.

The act requires that all research grants approved by the surgeon general must receive prior recommendation by the national advisory councils —comprised, for the most part, of nonfederal authorities in various spheres—established for this purpose. To assist the councils on highly technical matters, study sections of experts in about twenty special fields were appointed. These groups, including one in sanitary engineering or environmental health, have two major responsibilities: to review applications for research grants and provide technical advice on action to be taken and to survey the total research being conducted in each particular field in order to stimulate additional work in neglected areas. Thus, the councils and study sections have, therefore, responsibility for a major portion of the guidance and administration of the program.

The Sanitary Engineering and Occupational Health Study Sec., at first called the Sanitation Study Sec., organized in the fall of 1946, was composed of fifteen individuals, mostly from nonfederal institutions, who were recognized as authorities in the sanitary sciences, such as milk and food sanitation, insect and rodent control, water supply, stream sanitation, sewage and industrial wastes, industrial hygiene, and atmospheric pollution. Each year, about 25 per cent of the membership of the section is replaced to assure flexibility in the development of research programs.

Institutional Affiliation

Individuals find it advantageous to affiliate with universities or institutions because such union smooths the administration of the grant, provides the research worker with better facilities, and promotes collaboration with colleagues in related fields. Research projects related to sanitary engineering or environmental health are eligible for support as long as they bear directly or indirectly upon problems of health or disease. Projects exclusively or predominantly of local importance, and those which merely demonstrate the application of accepted scientific techniques, are usually not recommended for financial aid.

The aim of the Public Health Service is to promote the highest quality of endeavors in both fundamental and applied research, without restrictive regulations. Complete scientific freedom is accorded the investigator. Although applications for grants are evaluated primarily on the basis of scientific merit of the proposal, the worker is free to modify his research design as the study progresses, and to publish his results as he sees fit.

Every effort is made to ensure that Public Health Service research grants do not pose any administrative problems for the institution where the application is being made. To this end, the service has adopted these policy guides:

1. Each grant must be approved by the dean or other administrative officer in charge, on the assumption that he will assume responsibility for keeping salaries in line with others at the institution.

2. All or part of the salary of professional personnel may be paid from research grant funds to the extent that it has previously been supplied from other than regular institution funds.

3. Summer salaries may be paid only where assurance is given that the institution allows its employees to accept extra compensation for summer or vacation service, whether rendered to the institution or to others.

4. Travel funds may be used for travel incidental to the successful prosecution of the research project, but not for foreign travel to international meetings.

5. Equipment purchased with research grant funds becomes the property of the institution receiving the grant.

6. Grants may not be used to free the institution of its normal administrative responsibilities.

7. Grants are made on the principle of supplying money for 1 year, with a moral commitment for an additional 2–4 years.

Criteria for Grants

It is important to note that the title "Research Grant" connotes a distinction between projects that are only demonstration or control measures and those that are research. It is realized that many projects in environmental health are a combination of demonstration, control, and research activities. In such instances, the study section must make the sometimes difficult decision as to where the true emphasis lies. Research either constitutes experiment or theoretical analysis leading to increased knowledge of natural phenomena or is a collection of information needed prior to research projects for their proper conduct. In the field of environmental health, research may in-

clude the application of any basic data toward devising a new technique or piece of equipment or may be merely the testing of such methods or apparatus for the purpose of determining clinical or experimental uses. A project may satisfy these requirements and still not merit support. Each application must be judged by these criteria:

1. Is the investigator competent to do the proposed work?

2. Is the problem significant to medical or closely allied research?

3. Will the applicant have the necessary facilities to do the work?

4. Does the project director have so many other responsibilities that he cannot give the necessary time to the research?

5. Is the requested budget reasonable in relation to the work proposed?

6. Is the proposal clearly defined and planned, with comprehension of previous work related to the problem?

7. Is necessary collaboration from fellow scientists or other agencies definitely assured?

Too Little Water Research

Since inception of the program, 126 projects (Table 1) have been supported in the field of sanitary engineering and environmental health through recommendation of the study section and the national advisory council concerned. Such grants have been made in a total of 53 institutions, primarily the graduate departments of colleges and universities of 23 states.

Table 1 shows that, since the beginning of the program, only 32 projects amounting to $588,562, have been activated in the field of water supply, or an average of only four projects at a total of $73,570 annually. In proportion to its importance, research in water control activities from the viewpoint of developing fundamental knowledge has made little advance, at least in this program. Leaders in the field have pointed out that little has been accomplished for many years in basic studies leading to better chemical or biological analytic techniques and treatment processes. Of a total of $120,000,000 appropriated in support of all medical and allied research in the program of the Div. of Research Grants from 1947 to 1954, the $588,562 for water research represents only 0.5 per cent.

TABLE 1

Supported Projects

Category	Number of Projects	Amount Approved $
Water	32	588,562
Sewage	31	707,781
Industrial wastes and stream sanitation	16	292,859
Air hygiene	16	599,179
Food	12	187,751
Rodent control	4	98,510
Insect control	5	106,119
Milk and milk products	6	80,335
Swimming waters	2	6,808
Garbage disposal	2	34,500
Total	126	2,702,404

The related sphere of sewage and industrial wastes, with 47 research projects amounting to approximately $1,000,000, has received 0.8 per cent of the total funds appropriated. Although growth of the entire program in terms of funds (beginning with an annual appropriation of $3,437,000 in 1947 and gradually rising to $28,866,000 in 1954) has been very gratifying, the rate of grants in environmental health has not increased in relative proportion but, rather, has greatly de-

creased. For example, the support for the whole field of environmental health was 1.7 per cent of the total funds granted in 1947, but declined to 0.3 per cent of those for 1954. These figures also reflect a reduction of support in water supply, sewage and industrial wastes, and stream sanitation. Table 2 presents a list of water research projects currently in progress.

TABLE 2

Current Water Supply Projects

Project Number	Title	Investigator	Institution
D-183	Ion Exchange Resins for the Removal of Fluoride Ion From Drinking Water	E. A. Savinelli	University of Florida
D-192	Determination of Fluorine in Water	F. I. Brownley Jr.	Clemson College
E-153(C3)	Fungi in Drinking-Water Supplies	D. F. Metzler	University of Kansas
E-239	Coliform Population in Lake Waters	L. R. Hedrick	Illinois Institute of Technology
E-248(C2)	Nitrification of Soils in Relation to Infant Methemoglobinemia	E. L. Schmidt	University of Minnesota
E-651	Destruction of Cysts of *Endameba histolytica* in Water	Shih L. Chang	Harvard University
E-822	Ground Water Pollution as Affected by Fluctuating Water Table	G. H. Dunstan	State College of Washington
G-2071(C5)	Nutrition and Physiology of Blue-green Algae	F. Skoog G. C. Gerloff	University of Wisconsin
G-3216(C2)	Nutrition of the Planktonic Micro-organisms in Public Water Supplies	Luigi Provasoli	Haskins Lab., Inc.
G-3726(R)	Method of Evaluation of the Taste of Water	G. J. Cox	University of Pittsburgh
G-3965(R)	The Effects of Hardness of Water and Low Dissolved Oxygen on the Toxicity of Certain Chemicals	Ruth Patrick	Academy of Natural Sciences of Philadelphia
G-4007(R)	Effect of Water Treatment Methods on Water Main Carrying Capacity	A. M. Buswell	Illinois State Water Survey Div.
G-4009(R)	Toxicity Studies on Cadmium and Hexavalent Chromium in Public Water Supplies	R. U. Byerrum C. A. Hoppert B. V. Alfredson	Michigan State University
G-4058	Mayflies of the Southeastern United States	Lewis Berner	University of Florida
RG-4279	Toxic Properties of the Blue-green Algae	F. F. Davidson	Baylor University

Public Health Service consultants who are and have been members of the study section have advised that additional research should be initiated in water supply, as well as in the broader scope of environmental health. The consensus of these advisors is that the following problems need further development:

1. *Environmental health*—Pasteurization processes of milk and milk products; studies on pathogens in relation to frozen foods and other food products; problems of atmospheric pollution in relation to radioactive material; studies pertaining to bacterial, chemical, and physical aspects of air pollution for the control of virus infections and toxic substances; studies on the biology of poisons and insecticides as related to rodent and insect control; hygiene in housing; accident prevention.

2. *Sewage and industrial wastes*—More economic methods and improved scientific techniques for biological, chemical, and physical analyses of water, sewage, and industrial wastes, in order to ensure safe drinking water supplies and to prevent stream pollution.

The discussions of study section and council members and the types of proposals that have been submitted for investigation have indicated many of the areas that need further investiga-

tion in the water pollution field. Among these are: [1] studies on biological indexes of pollution; [2] effects of pollution abatement practices on affected streams; [3] effects of pollution on marine areas and estuaries; [4] reappraisal of standard maximum density of coliform bacteria in sources of public water supplies; [5] basic study of the biological factors governing the assimilative capacities of receiving waters for nontoxic organic matter; [6] evaluation of natural purification by reaeration, photosynthesis, and other factors; [7] development of basic and precise methods for taste and odor control; and [8] establishment of reliable criteria for various usages of receiving water, especially dissolved oxygen levels necessary to the maintenance of all forms of aquatic life.

Developing Research

There are substantial ways to develop, stimulate, and encourage research potential from the standpoint of personnel and facilities. One method might be through the efforts of the AWWA Research Committee in conducting a survey among consulting engineers, water works superintendents, industrial technologists, personnel of equipment manufacturers, research and educational personnel, and others to determine the selection of problems for investigation and to distribute the findings through published reports. The next step might be to visit universities and other institutions capable of conducting projects in order to discuss the water supply problem and to stimulate cooperative interest at such places, especially in the graduate departments of chemistry, physics, biology, bacteriology, pathology, physiology, toxicology, and civil and sanitary engineering, because it takes the combined knowledge of all of these disciplines to promote and accomplish some of the best basic studies.

Through the mechanism of the Public Health Service research grant operation, funds are available for good proposals,* but it is certain that to accomplish the tasks in the vast and important field of water supply, much aid in the preliminary organization will have to come in large measure from the interest shown in professional groups such as AWWA. Obviously, money alone does not develop good research. There is a necessity for the training of research scientists in sanitary engineering and related disciplines at the graduate level, with the ground work to be laid for preparation of such persons at the undergraduate level. This step can be achieved through careful planning with the aid of the active organizations concerned, whether the stimulus be from university professors or research committees of the professional societies. Within the framework of the Research Grants Div. is a fellowship program which provides stipends for the training of research scientists through the master's and doctor's level in all facets of medical and related research, including sanitation. There has been only a handful of students in the sanitary sciences, compared to the hundreds in other medical and related fields that have applied for and taken advantage of this opportunity. Personnel properly oriented and trained will serve as one of

* It is anticipated that the Congress will appropriate special funds for sanitation research grants which will become available July 1, 1956. In the meantime, all sanitary research studies presently financed by the N.I.H. will continue to receive funds to complete the projects.—*Editor.*

the most significant long-term stepping stones in satisfying the many unanswered questions of water pollution.

The Public Health Service, through its Div. of Research Grants, is prepared to cooperate in the further advancement of research that is directly of concern to AWWA and other groups and would appreciate any assistance that the Association can lend toward development, encouragement, stimulation, and increase of research activities. Support in this direction might be gained through meetings of some of the staff of the Public Health Service with designated members of the AWWA Research Committee to discuss mutual interests for the purpose of taking positive action.

Requests for a grant should be submitted by an institution on behalf of an investigator's research, using special forms which may be obtained by writing to the Div. of Research Grants.* Included with the application will be instructions for its preparation, a statement of policy of the program, and the appropriate dates for presentation. Such proposals in almost all instances will reflect the initiative and originality of the investigator.

* National Institutes of Health, Bethesda 14, Md.

Reprints Available

Reprints of the following articles, published in the Journal during the preceding year, will be available from the Association in small quantities, at the prices noted, until the present stock is exhausted. Order by reprint number and author's name from: Order Dept., American Water Works Assn., Inc., 521 Fifth Avenue, New York 17, N.Y. **Prepayment required on orders under $2.** (Note: This list does not include specifications and similar documents kept permanently in stock.)

Reprint No.	Author	Title	Issue of Journal	No. of Pages	Price per Copy
372	Paul	Valve Selection	Nov 54	20	30¢
373	Cunningham	Wood Stave Pipe	Nov 54	10	25¢
374	Chlorine Institute	Stationary Chlorine Storage	Nov 54	12	25¢
375	Wolman	Providing Water Service	Jan 55	8	20¢
376	Panel Discussion	Ohio Fringe Area Service	Feb 55	9	25¢
377	Joseph, Maguire	New-Utility Problems	Feb 55	6	20¢
378	Berger, Stevenson	Biological Warfare	Feb 55	10	25¢
379	Niles	Construction Cost Variations	Mar 55	8	20¢
380	Mallmann, Fontes	Drinking Fountains	Mar 55	8	20¢
381	Kelly	Infestation at Norwich	Apr 55	7	20¢
382	Popalisky	Water Heater Reactions	Apr 55	5	20¢
383	Griffith, Holsinger, Chase	Planning and Legal Aspects of California Supply	Apr 55	22	35¢
384	Hathaway	Legal Liability	Apr 55	4	15¢
385	Nesheim	FCDA Contributions	Apr 55	3	15¢
386	Garrity, Niemeyer	Sulfur Compound Joints	May 55	17	30¢
387	AWWA Report	Utility Employment Conditions	May 55	11	35¢
388	Swanson et al.	Wye Branch Design	Jun 55	52	80¢
389	Luce	Sizing Water Mains	Jul 55	5	20¢
390	Howson, Aultman, Gallaher	Treatment Plant Design	Aug 55	9	25¢
391	Gidley	Municipal Management	Jun 55	4	15¢

Labor Department Survey of Injury Rates in Water Industry

G. R. McCormack

A paper presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill., by G. R. McCormack, Chief, Special Studies Section, Branch of Industrial Hazards, Bureau of Labor Statistics, US Dept. of Labor, Washington, D.C.

PRIOR to 1925, the US Bureau of Labor Statistics' work in the safety field dealt primarily with workmen's compensation problems and hazards associated with particular industrial operations. In 1925 an injury rate series was inaugurated which included 24 broad manufacturing industries. The series has been revised and expanded several times so that at present the surveys include more than 200 manufacturing and nonmanufacturing industry classifications. Water works were covered for the first time in 1939.

The bureau's program in this field is designed to service the occupational safety movement. Through its regular injury rate surveys and estimates of the number of disabling injuries occurring in industry, the program creates and maintains interest in accident prevention by providing national indicators of the magnitude of the injury problem. Further, it provides a measure of the relative level of injury occurrence in various segments of industry and indicates the progress achieved in the prevention of injuries from year to year.

Special Surveys

In 1942, as a further service to industry, the bureau began a series of detailed industry surveys such as the one which is being conducted currently in the water works industry. These special one-time surveys are designed to provide the basic data on injuries and accidents which are necessary for effective planning of accident prevention programs. Usually these surveys are conducted in two separate steps: first, a detailed injury rate survey; and second, a study of accident types and causes.

For the injury rate study, a special questionnaire or report form is developed for the industry being surveyed. Basically, the questionnaire represents a request that each cooperating establishment report its injury experience by department, operation, or occupation, depending on the way the particular industry is organized. Relatively large reporting samples are required because the data collected are quite detailed. Sampling techniques are therefore used only in the largest industries. The injury rate studies are conducted primarily by mail, and reporting is voluntary. From these reports, injury frequency and severity measures are computed for each type of operation found in the industry, and for establishments of various sizes in different geographic areas. Thus, it

is possible to see which parts of the industry have adverse injury rates and, consequently, to determine where safety activities should be concentrated. The study also enables the plant owner or manager to compare the injury experience of his plant or departments with large similar groups of workers.

For the accident cause studies, bureau representatives collect the data by visiting the cooperating establishments. The data collected consist of detailed case records of individual accidents listing all available information relating to each occurrence. This information is obtained from the original accident records of the establishment, supplemented by personal discussions with informed persons and frequently by observation of the operation in which the accident occurred. The objective is to determine for each accident: [1] how, when, and where it occurred; [2] what unsafe act and hazardous working condition contributed to its occurrence; and [3] what type of injury resulted. Because these data are collected by personal visits and the number of bureau employees available for this work is limited, the accident cause studies are based on small samples of firms in each industry.

The resulting case records are analyzed individually according to a modification of the "American Recommended Practice for Compiling Industrial Accident Causes" *(1)*. When these data are summarized, it is possible to determine the specific hazards which are most commonly responsible for accidents in the industry and to relate them to particular items of equipment. With this information at hand, it is possible to plan a safety program which, if carried through, can reasonably be expected to reduce the number of accidents.

In regard to the water utility industry, the injury rate portion of the special study has been completed and the final report on that part of the survey is now available.* Data for the accident cause study have been collected and an analysis of the individual cases has been made, but, because of the bureau's other commitments, the overall analysis of the data and the publication of the final report for that part of the survey will not be completed before 1957. Consequently, this report is based solely on the injury rate portion of the survey.

Water Industry Sample

According to the US Dept. of Health, Education, and Welfare, approximately 17,000 communities were served by public water supplies in 1948. For the special injury survey, the sample selected included all municipalities having 5,000 or more population and 25 per cent of those having less than 5,000. This gave a mailing list of of 5,623 political subdivisions. Detailed and usable reports were received from 3,121 water works, about nineteen times as many as have been included in recent annual surveys. These water works employed more than 64,000 workmen during 1953, approximately 55 per cent of the industry's total employment.

Because the sample on which the survey was based included only a percentage of those communities with a population under 5,000, these smaller divisions were inadequately represented and an adjustment had to be made. The injury frequency rates, therefore, were computed by weighting the injury experience of each population

* Copies may be secured on request from the Bureau of Labor Statistics, US Dept. of Labor, Washington 25, D.C.

group by its respective estimated employment. The weighted rate was 22.2. The unweighted average was 24.8.

Injury Frequency Rate

The term "injury frequency rate" is defined as the number of disabling injuries which occur per 1,000,000 hr worked. The rate roughly represents the number of disabling injuries which 500 men working a 40-hr week would suffer during a year's time. A disabling injury is defined as any injury which results in death, in some degree of permanent impairment, or in a loss of at least one full day from a regularly established job.

Figure 1 compares the yearly fluctuations of the injury frequency rates for the water utility industry with the rates in construction and all manufacturing. In the early years of the survey the sample for the industry was very small. Those years and the succeeding war years have been excluded from the chart.

The injury frequency rate for water works is seen in Fig. 1 to have risen from 18.0 in 1946, the first postwar year, to 22.2 in 1953. At no time since 1946 has the frequency rate for the industry been below 21. The rate for all manufacturing, compiled from large representative samples of the industries included, exceeded the rate for the water utility industry by 10 per cent in 1946. From that time on, however, in contrast to the general increase in water works rates, the all-manufacturing rate improved by falling to 13.4 in 1953, when the water industry rate exceeded it by 66 per cent.

The bureau found that 46 per cent of the workers covered in the special survey were engaged in water works construction and maintenance. The average frequency rate for all construction activities is therefore included in Fig. 1. Compared with this, the level of injury frequency rates in water utilities is favorable. The frequency rate for construction, however, followed the trend set by manufacturing generally, and the 55 per cent gap between the water works and construction rates in 1946 has been narrowed to 33 per cent in 1953.

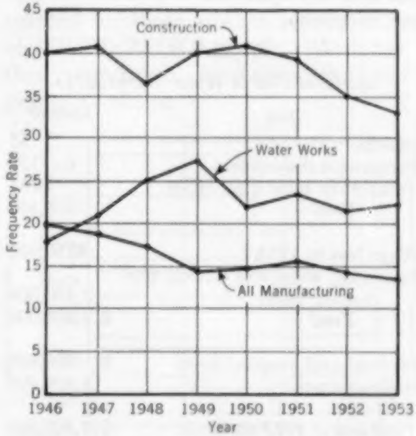


Fig. 1. Injury Frequency Rates

The injury frequency rate is the average number of disabling injuries which occur in a given industry for each 1,000,000 hr worked. This illustration compares injury frequency rates of the water works industry with those of construction and all manufacturing for the period 1946–53.

Cost of Accidents

Table 1 summarizes the estimated cost of 1953 accidents in the water utility industry. The industry record indicates that one out of 22 water works employees suffered a disabling injury during 1953. This means that an estimated 5,300 workers in the entire industry experienced disabling in-

juries during that year. Approximately 35 of these workers died as a result of their injuries and 120 others were permanently disabled in some degree by the loss or impairment of some body part or function. The remaining 5,145 workers were more fortunate in that they suffered no permanent ill effects, but each was injured seriously enough to require at least one full day for recovery.

TABLE 1

Accident Toll in Water Works, 1953

Item	Amount*
Deaths	35
Permanent disabilities	120
Temporary total disabilities	5,145
Total	5,300
Wage loss in 1953	$750,000
Economic wage loss during succeeding years	2,850,000
Total	$ 3,600,000
Medical and hospital costs	$ 500,000
Indirect costs	8,400,000
Total cost of 1953 accidents	$12,500,000

* All amounts are estimated.

The actual time lost due to these injuries is estimated at about 82,150 man-days of work during 1953. According to a US Census Bureau release, the average earnings during October 1953 for employees of water works operated by local governments was $262.89. Assuming that average to be representative for all workmen in the industry and for the entire year, the wage loss due to work injuries was nearly $750,000 during 1953.

But the time lost does not adequately measure the real work loss resulting from these injuries. Many of the permanently injured workers will have their earning ability reduced for the remainder of their lives. For those fatally injured, the loss is equivalent to the total earnings they would have received had not their careers been cut short. If allowance is made for these continuing losses, the total economic loss is estimated at 408,000 man-days. Based on the average earnings of October 1953, the total economic wage loss is approximately $3,600,000. In part, this loss is covered by workmen's compensation payments financed by employers, but these payments are seldom equivalent to full wages. As a result, the workman must bear a considerable portion of the loss himself.

In addition to wage losses, payments for medical and hospital care and many other indirect costs contribute to the total cost of injury-producing accidents. Among these indirect costs are damage to equipment and materials, the cost of training replacement workers, time lost by other workers who stopped working at the time of the accident, and supervisory time spent in caring for the injured, investigating the accident, and reorganizing the work after the accident. These indirect costs of accidents are seldom recorded and cannot be determined accurately, but studies by H. W. Heinrich (*2*) of the Travelers Insurance Co. indicate that, for manufacturing generally, the average indirect costs arising from injury-producing accidents amount to about four times the total of compensation, hospital, and medical payments. Assuming that ratio to be approximately correct for the water works industry, the estimated indirect costs of injury-producing accidents during 1953 was $8,400,000 and the total costs, including medical expense, amounted to $12,500,000.

Public and Private Ownership

Overall frequency rates varied little between publicly and privately oper-

ated water works. The injury frequency rate of 24.8 for publicly operated water utilities was less than 6 per cent greater than the rate of 23.5 for those privately operated. Actually, the disparity between the two rates was due entirely to the difference in the amount of hazardous construction and maintenance work performed by the two groups. Approximately 46 per cent of the employees reported by publicly operated water works were engaged in construction and maintenance activities. In privately operated water

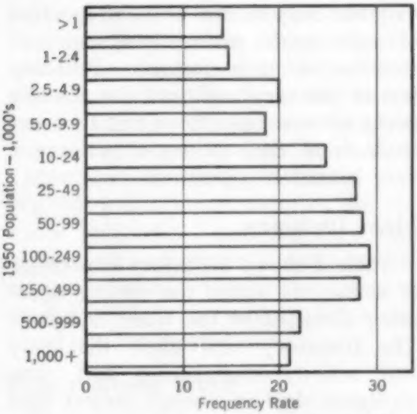


Fig. 2. Frequency Rates for 1953 Related to Population Served

Small and large utilities generally have better injury frequency rates than the medium-sized utilities.

utilities, these operations accounted for only 38 per cent of all employees. Excluding the injury experience of these workers, the injury frequency rate for publicly operated water works was 12.9, as compared with 13.7 for privately operated utilities.

Size of Plant

Figure 2 shows the frequency of injuries in relation to the population of the community served. To assure consistency in the population figures, this tabulation was based on the population of the largest community served by each utility as given by the 1950 census. The most favorable injury frequency rates occur in the smallest political subdivisions. As population increases, injury frequency rates also increase, until a maximum of 29.2 is reached for those utilities serving cities of 100,000–249,000 people. With further population increases, the rate gradually drops.

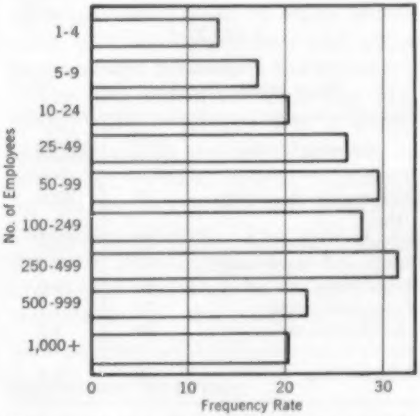


Fig. 3. Frequency Rates for 1953 Related to Size of Water Works

The pattern is similar to that in Fig. 2.

In Fig. 3, injury frequency rates are related to the size of the utility as measured by average employment. Because the number of employees is loosely determined by the size of the population served, the patterns of injury frequency rates shown in Fig. 2 and 3 are similar. These rates are averages, however, and should not be construed to mean that utilities serving populations of 100,000–249,000 or employing 250–499 workers necessarily have the worst rates. In fact, the sur-

vey indicates that some utilities in each size group up to the 250-employee level had zero frequency rates and that some utilities in each group up to the 1,000-employee level had rates of less than five. It is apparent, therefore, that injury frequency rates are not solely dependent on the size of the utility.

Conclusive proof as to the reason for the pattern is not available, but the same situation exists in most of the bureau's special studies. In general, smaller establishments have favorable rates, but as the size of the establishment increases, the average rates gradually increase until a maximum is reached near the 250-employee level. With further increases, the rates gradually go down.

TABLE 2

Severity and Frequency of Injuries in Water Works Divisions, 1953

Operating Division	Injury Severity*	Injury Frequency
Engineering & construction	55	39.1
Outside commercial	21	23.2
Pumping & water supply	51	17.1
Meter shop	85	16.6
Water treatment	70	13.9
Administration	29	5.6
Industry avg	58	24.6

* Average number of days lost or charged per disabling injury.

In explanation of the pattern, it has been reasoned that the manager or owner of a smaller establishment actually takes part in plant production activities and directly supervises most operations. In this way, he can correct hazards and unsafe working conditions as they develop and to some extent can control unsafe personal actions. As plant size increases, however, more of his time is required for administrative details, and he must delegate production responsibilities to foremen who are seldom trained in safety. Thus, there is an increase in the injury frequency rate. At some point, however—apparently near the 250-employee level—accidents become such a problem that special attention must be given to them. As a result, safety programs are developed which reduce the toll of accidents.

These premises probably apply in some degree to water utilities as well as to industry in general. In addition, for the water industry, some of the variation may be due to the proportion of water works maintenance and construction work performed. Probably few of the very small utilities actually perform those operations and thus exclude from their injury experience a very hazardous operation.

Plant Divisions

Table 2 shows the injury experience of employees within the various operating divisions of the water industry. The frequency rates show that only one activity—engineering and construction—had an average greater than the industry average, but outside-commercial divisions had a rate only a little below the average. The administrative and water treatment divisions achieved the best frequency rate averages. On an average, injuries are most severe in meter shops and water treatment divisions and least severe in the outside-commercial divisions.

Reference

1. American Recommended Practice for Compiling Industrial Accident Causes—ASA Z16.2. Am. Standards Assn., New York (1941).
2. Heinrich, H. W. *Industrial Accident Prevention*. McGraw Hill Pub. Co. (3rd ed., 1950). p. 50.

Successful Safety Program in Oakland, California

William J. Stephens

A paper presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill., by William J. Stephens, Personnel Mgr., East Bay Munic. Utility Dist., Oakland, Calif.

FOR every 500 employees in the water industry during 1953, 22 missed at least one day of work because of injuries incurred on the job. In one utility, injuries were so prevalent that one out of every five workers was missing from his work unit at one time or another. These were the startling facts found by the Bureau of Labor Statistics during its recent survey of job-incurred injuries in the water industries. But this high rate of accident occurrence is not a necessary condition. The water industry need not have a safety philosophy based on "calculated risk."

Safety Means Work

There is no shortcut or cure-all for accident prevention. The basis for any safety program is to do something about accident prevention and then to continue doing it. Safety programs have to be planned and geared to the size of the utility and the type of people employed by it. To build such a program and to make it successful, top management must actively support and participate in it. There is no substitute for work. Wanting to cut down accidents and holding a meeting to discuss plans does not make a safety program. The program must be planned and worked at, and there must be someone in the organization whose job it is to think constantly of safety. It must include not only top management, but all levels of supervision, and all employees. Each of these groups must give its cooperation and active support.

The program of the East Bay Municipal Utility District has a simple philosophy and definite objectives to which are applied special techniques for accomplishing the end result of preventing injuries. The basis of the district's program has been to make every man feel that he is personally responsible for the safety of himself and his fellow workers.

Committee Structure

A general safety committee consisting of top management was appointed by the general manager. This group is directly responsible for the establishment of safety policies. The safety committee appoints a planning subcommittee, including a safety coordinator, which plans the annual safety programs and establishes blueprints and timetables for these projects. The details of accomplishment are left to the safety coordinator, following policies laid out by the general safety committee.

Five additional committees, composed of employees from the various areas of operation, are responsible to

the general safety committee. In each of the smaller committees, people like pipemen, clerks, supervisors, machinists, and accountants meet monthly to plan ways of making their specific work areas safer. These smaller committees are appointed for six-month terms and the members serve as the safety representatives of the people in their work area or unit. They discuss hazards with their supervisors and work with them to correct these hazards. Committee members are responsible for helping to prevent injury or loss of time due to accidents, and they act as a liaison between management, supervisors, safety committees, and their fellow employees.

Planning

Last year the planning subcommittee proposed to integrate safety in job instructions. It suggested that a safety manual be completed, that "pipeline conferences" be continued, that new employees be interviewed and more carefully oriented to the hazards of their job. The planning activity of the safety committee is of vital importance because it establishes the objectives that result from division managers' planning. This paves the way for the safety unit to attack its problems without worrying about cooperation from key personnel.

Inspection

Regular inspection of the premises by a trained safety inspector is a basic necessity. People working in an unsafe area too often tend to overlook, ignore, or minimize the hazards. In planning, designers sometimes overlook handrails, and possibilities of tripping or falling. Tools and ladders develop weaknesses even though purchased from the best suppliers, and structures often deteriorate in unexpected ways, becoming hazards to employees and the public. Regularly scheduled inspections eliminate injuries by uncovering many of these conditions.

Useful Techniques

An ingenious safety man can be most useful in devising new approaches to make employees continuously aware of safe working practices. It is important that a safety program does not become stereotyped and it must not be given lip service only.

At East Bay Dist., weekly "pipeline conferences" are held. These are eight-minute safety talks given by supervisors to their men at the job site to maintain fresh safety viewpoints. The conferences cover a range of subjects from spoil bank and shoring hazards to compensation or driving problems. This form of education seems to accomplish the best results with the least amount of effort. The supervisor actually tells his men as a group how to work safely. A repetition of this activity over a period of time makes safety a habit.

There is an accident review board to review both lost-time injuries and automobile accidents. This is another technique which works toward keeping all employees constantly aware of safe work habits. The board reports directly to the general manager, indicating what action is to be taken and by whom. The investigative bodies are solely fact-finding.

Contests are conducted to stimulate talk about safety, and safety competition between various sections of the district is encouraged and fostered by our safety program. A special bulletin board at the main corporation yard shows how many days the district has

gone without a lost-time accident and compares the status of the current year with the same date the previous year. Other attention-getters, like posters, are valuable aids to basic objectives, but they should not be used unless they are part of a planned project. For example, a recent safety slogan contest, because it had a direct purpose in the district's planned safety events, made people aware of the cause of and cure for accidents. A follow-up to the contest will consist of publicizing the best slogans.

Results

There is no doubt that the safety program of the East Bay Dist. is effective and will continue to bring planned results. The water works injury frequency in 1953 was over 20 accidents per 1,000,000 man hours. At one time the district's frequency rate was 20 accidents per 1,000,000 man hours, but it dropped to 11.48 in 1953. In 1954 it dropped to 6.98, and over the past twelve months there has been a cumulated frequency of 3.00. In 1954 the district received a $45,000 dividend on its insurance premium followed by an 18 per cent reduction in premium rate. The 1955 dividend exceeded this. During one period in 1954, 1,000,000 consecutive man hours were worked without a lost-time accident. These are real profit items that cannot be ignored by any business.

Conclusion

Safety involves a lot of people. It requires constant attention by all employees and a safety staff which will continually inject new ideas to keep the program from becoming commonplace and ineffectual. The experience at East Bay Municipal Utility Dist. has shown that a safety program needs a planned approach, planned objectives, and a specific person responsible to assure all concerned that the planning is carried out. No one wants accidents to occur, and it is the job of the entire management staff to see that they are prevented.

Charges for Residential Air Conditioning

Committee Report

A committee report presented on Jun. 13, 1955, at the Annual Conference, Chicago, Ill., by Frank C. Amsbary Jr., Chairman, Committee 4130M—Water Use in Air Conditioning and Other Refrigeration. The other members of the committee were: E. L. Bean, M. C. Smith, and L. L. Lewis.

THE purpose of this report is to clarify certain misinterpretations of the committee's previous findings. It was with reluctance that this committee acceded to the request of the AWWA and prepared a model ordinance to be used as a guide by those communities in which restrictive measures were known to be necessary (*1*). Nothing in any part of the accompanying reports could be interpreted as a recommendation that this ordinance be adopted intact by every community and without regard to widely differing local situations. Since the model ordinance was published, however, the introduction of air conditioning in residential premises has vastly altered the problem. The regional percentage of national sales is shown in Table 1. It is now believed that these domestic installations will far exceed the installed capacity in commercial establishments. Past and predicted future sales of residential year-round air-conditioning systems in the United States for the period 1954–58 are shown in Table 2. Table 3 shows the estimated dollar volume of sales for those years. Because of the immensity of these figures, and because the water distribution systems in residential areas usually have less reserve capacity and are already subject to the coincident seasonal demand of lawn sprinkling and swimming pools, the committee recommends that no exception be made in the size of air-conditioning units as suggested in Sec. 7 of the model ordinance. In two of its previous reports the committee suggested that the only equitable way for the water purveyor to be paid the added cost of low-load-factor water uses was by the application of special rates based upon the demand for water used for air conditioning and other such seasonal purposes. This demand charge may be either a higher rate charged for water so used when separately metered or, in the case of air conditioning, a fixed annual charge based on the tonnage capacity of the units installed plus the charge at regular rates for water consumed. The committee was supported in this opinion by the report of the AWWA Committee on Water Rates (*4*). It should

TABLE 1

*Regional Percentage of National Sales in the Past**

Region	Sales *per cent*
Calif., Ore., Wash.	1.68
N.M., Ariz., Nev., Colo., Utah, Wyo., Idaho, Mont.	0.66
N.D., S.D., Minn., Neb., Iowa, Kan., Mo.	6.60
Okla., Tex., Ark., La.	30.59
Wis., Ill., Ind., Ohio, Mich.	9.69
Ky., Tenn., Miss., Ala.	8.72
New England	3.71
N.Y., Pa., N.J.	23.88
W.Va., Va., N.C., S.C., Ga., Fla., Md., Del.	14.47

* From *Monsanto Magazine* (*2*).

TABLE 2

*Present and Predicted Number of US Homes Fully Air Conditioned, 1954–58**

Year	No. of Homes
1954	120,000
1955	240,000
1956	360,000
1957	540,000
1958	700,000
Total	1,960,000

* Data from the American Inst. of Management (*3*).

TABLE 3

*Volume of National Sales of Residential Air Conditioning, 1954–58**

Year	Sales
1954	$ 750,000,000
1955	900,000,000
1956	1,050,000,000
1957	1,200,000,000
1958	1,350,000,000
Total	$5,250,000,000

* Data from the American Inst. of Management (*3*).

be noted that demand charges are recommended by these committees for the further purpose of forcibly encouraging the use of water conservation towers, evaporative condensers, and the like by omitting such demand charges if the consumer installs these conservation appliances himself. Thus, a demand charge may be computed so as to encourage the use of available water conservation appliances or properly to force the seasonal user to pay the true cost of serving him.

The first demand charge of record was reported in 1953 by J. R. Pierce, Vice-Pres. and Gen. Mgr., General Water Works Corp. (*5*). This report told of the Arkansas Public Service Commission's approval of a demand charge of $12.50 per ton per year to be charged by that company for nonconserved water used in air conditioning, and the method used in computing the charge. Since that report, Atlantic, Iowa, has adopted a demand charge of $10 per year per ton for nonconserved water usage in air conditioning, and the Missouri Public Service Commission has approved a demand charge for the St. Louis County Water Co. of $40 per ton per year. Also, the approval of a demand charge will soon be requested of the Illinois Commerce Commission by at least two utilities. Other controls or special charges adopted by various municipalities are shown in Table 4.

It can no longer be said that the application of sufficiently increased rates to cover the actual added cost of water used only seasonally will deny water users the comforts of air conditioning. Upon request, the committee has endeavored to determine the impact of air conditioning on the load growth of water utilities. Unfortunately, there appears to be no guide that will be of value to any specific community.

The committee is fully conscious of the fact that water use in air conditioning is only one of the many low-load-factor uses and again it recommends that the AWWA appoint other committees to make a complete study to determine what other possible water uses should properly and may feasibly be placed under special rates or regulations like those recommended for water used in air conditioning.

References

1. Committee Report. Regulation of Air Conditioning and Other Refrigeration. *Jour. AWWA,* **42**:1111 (Dec. 1950). Copies of Reprint No. 263, containing the model ordinance, are available from AWWA at 20¢ each.
2. *Monsanto Magazine* (midsummer 1954).
3. American Inst. of Management (Sept. 1953).
4. Committee Report. Determination of Water Rate Schedules. *Jour. AWWA,* **46**:187 (Mar. 1954).
5. Committee Report. The Problem of Air-Conditioning Water Use. *Jour. AWWA,* **45**:867 (Aug. 1953).

TABLE 4—*Control of Water Use for Air Conditioning in US Cities**

City and State	City and State	City and State	City and State
By Department or Company Regulation			
Albuquerque, N.M.	Enid, Okla.	Medford, Ore.	Pueblo, Colo.
Alhambra, Calif.	Evanston, Ill.	Memphis, Tenn.	Raritan Twp., N.J.
Arlington Co., Va.	Fanwood, N.J.	Meridian, Miss.	Rochester, N.Y.
Athens, Tenn.	Fresno, Calif.	Miami Beach, Fla.	Rolla, Mo.
Bangor, Me.	Garwood, N.J.	Midland, Tex.	Roselle, N.J.
Birmingham, Mich.	Green Brook Twp., N.J.	Montclair, N.J.	Roselle Park, N.J.
Canton, Miss.	Greenwood, Miss.	Mountainside, N.J.	Sacramento, Calif.
Carson City, Nev.	Hillside, N.J.	Mount Vernon, N.Y.	San Antonio, Tex.
Cedar Rapids, Iowa	Honolulu, Hawaii	National City, Calif.	Scotch Plains, N.J.
Chambersburg, Pa.	Hopkinsville, Ky.	New York, N.Y.	Selma, Calif.
Champaign-Urbana, Ill.	Inglewood, Calif.	North Plainfield, N.J.	Somerville, N.J.
Clark Twp., N.J.	Ithaca, N.Y.	Oklahoma City, Okla.	South Plainfield, N.J.
Coldwater, Mich.	Kansas City, Mo.	Orange, N.J.	Steubenville, Ohio
Compton, Calif.	Kenilworth, N.J.	Ossining, N.Y.	Tallahassee, Fla.
Cranford, N.J.	Kenosha, Wis.	Paducah, Ky.	Tucson, Ariz.
Dallas, Tex.	La Grange, Ill.	Pasadena, Calif.	Union, N.J.
Denver, Colo.	Lancaster, Pa.	Pensacola, Fla.	Washington, D.C.
Des Moines, Iowa	Lansdale, Pa.	Perth Amboy, N.J.	Washington Sub. San. Dist., Md.
Detroit, Mich.	Lawrence, Kan.	Philadelphia, Pa.	Watchung, N.J.
Dubuque, Iowa	Libertyville, Ill.	Phoenix, Ariz.	Westfield, N.J.
Dunellen, N.J.	Lincoln, Ill.	Piscataway, N.J.	Wilmington, Delaware
Elizabeth, N.J.	Linden, N.J.	Plainfield, N.J.	Winfield, Township, N.J.
Elmira, N.Y.	Manchester, N.H.	Pomona, Calif.	
By City Ordinance			
Albany, N.Y.	El Paso, Tex.	Mineola, N.Y.	Roswell, N.M.
Alexandria, Va.	Fargo, N.D.	Montclair, N.J.	Royal Oak, Mich.
Alliance, Ohio	Fond du Lac, Wis.	Muskegon, Mich.	Salina, Kan.
Amarillo, Tex.	Fort Worth, Tex.	Newark, N.J.	San Angelo, Tex.
Appleton, Wis.	Freeport, N.Y.	Newburgh, N.Y.	Schenectady, N.Y.
Bangor, Me.	Greenwood, Miss.	New Orleans, La.	South Orange, N.J.
Canton, Ohio	Hamtramck, Mich.	North Arlington, N.J.	Springfield, Ohio
Charleston, S.C.	Le Grange, Ill.	Oklahoma City, Okla.	Tarrytown, N.Y.
Cheyenne, Wyo.	Lawrence, Kan.	Orange, N.J.	Warrenton, N.C.
Clarendon Hills, Ill.	Lebanon, Pa.	Ossining, N.Y.	Washington, D.C.
Columbia, Mo.	Manchester, N.H.	Perth Amboy, N.J.	Webster City, Iowa
Dearborn, Mich.	Massapequa, N.Y.	Plainfield, N.J.	Wichita, Kansas
Detroit, Mich.	Memphis, Tenn.	Quincy, Mass.	Woodland, Calif.
Elmhurst, Ill.			
By Special Charge			
Albany, N.Y.	Duluth, Minn.	Kansas City, Mo.†	Moorehead, Minn.
Appleton, Wis.	Elkhart, Ind.	Kingston, N.Y.	Perth Amboy, N.J.
Atlantic, Iowa	Fargo, N.D.	Lima, Ohio	Pine Bluff, Ark.
Bangor, Me.	Independence, Kan.	Manchester, N.H.	Reno, Nevada
Burlington, Iowa	Independence, Mo.	Manhattan, Kan.	Springfield, Mass.
Cheyenne, Wyo.	Kankakee, Ill.	Meridian, Miss.	St. Louis County Water Co., Mo.
Decatur, Ill.	Kansas City, Mo.	Montclair, N.J.	
By Sewer Charge			
Jonesboro, Ark.	Mineola, N.Y.	Plainfield, N.J.	Spartanburg, S.C.
Marshalltown, Iowa	Owensboro, Ky.	South Bend, Ind.	
No Control			
Ames, Iowa	Emporia, Kan.	Miami, Fla.	Selma, Calif.
Anaconda, Mont.	Festus, Mo.	Morgantown, W.Va.	Shamokin, Pa.
Asheboro, N.C.	Forsyth, Mont.	Muscatine, Iowa	Sharon, Pa.
Birmingham, Ala.	Fort Dodge, Iowa	Newburgh, Ind.	South Bend, Ind.
Boone, Iowa	Griffin, Ga.	Newton, Iowa	St. Louis, Mo.
Cedar Rapids, Iowa	Hayward, Calif.	North Miami, Fla.	St. Paul, Minn.
Charleston, W.Va.	Highland Park, N.J.	Oskaloosa, Iowa	Utica, N.Y.
Charlevoix, Mich.	Iowa City, Iowa	Ottuma, Iowa	Ventura, Calif.
Chicago, Ill.	Kalamazoo, Mich.	Pittsburgh, Calif.	Waterloo, Iowa
Cleveland Hgts., Ohio	Keokuk, Iowa	Pittsburgh, Pa.	Waukegan, Ill.
Clinton, Iowa	La Mesa, Calif.	Port Chester, N.Y.	Wenatchee, Wash.
Crystal City, Mo.	Lexington, Ky.	Richmond, Va.	Whittier, Calif.
Davenport, Iowa	Longview, Wash.	Roanoke, Va.	Worcester, Mass.
De Queen, Ark.	Manville, N.J.	Rock Rapids, Iowa	Yardley, Pa.
Dorset, Vt.	Marshalltown, Iowa	Salinas, Calif.	Youngstown, Ohio
El Cajon, Calif.	Mason City, Iowa	San Francisco, Calif.	

* Recognition is given to Harris F. Seidel of Ames, Iowa, for his cooperative efforts in this survey. The high percentage of returns from Iowa included in this tabulation is the result of a questionnaire circulated by Seidel within that state. † Suburban.

Surcharge for Nonconserved Air Conditioning in St. Louis County

W. Victor Weir

A paper presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill., by W. Victor Weir, Pres. & Gen. Mgr., St. Louis County Water Co., St. Louis, Mo.

THE St. Louis County Water Co. is a privately owned public utility furnishing water to the various cities, towns, and unincorporated territory on the north, west, and south sides of St. Louis. This water works serves more than 120,000 accounts in a territory of more than 200 sq miles, which is essentially residential, inasmuch as only 5 per cent or 6 per cent of the supply is used for industry. Like other sections of the United States, the St. Louis metropolitan area has experienced its greatest growth outside the central city. Practically all of the new residential and commercial development is in St. Louis County, a situation that has resulted in an extraordinary increase of water customers, amounting to 87 per cent since 1946.

The St. Louis County Water Co. has been required to increase greatly the capacity of its plants, mains, and storage. Considerable difficulty has been encountered in doing this rapidly enough, although construction has consistently been ahead of customer growth. In 1952 there was a 7.5 per cent rise in customers, with a 24 per cent increase in the peak day use of water. In 1953 there was a 7.3 per cent rise in customers, with a 23 per cent increase in peak day use of water. In 1954 there was a 9.4 per cent rise in customers, with a 33 per cent increase in peak day use of water. In 3 years, customers increased 26.4 per cent while the peak day rose 102 per cent. In 1955 a 9 per cent rise in customers is expected, but capacity will be increased 42 per cent.

Air-Conditioning Study

Early in 1954, a study was started to determine if air conditioning was the factor causing the extraordinary peak loads. It was realized that such use was increasing, but the extent was not known. The first step was to ascertain the amount of the air-conditioning load. The Union Electric Co., the supplier of power in the area, had a supposedly complete record of all air-conditioning units attached to its system. This information was obtained and all data pertaining to St. Louis County were entered on cards. It was apparent that the statistics of the electric company were incomplete. For example, the water company office building, with about 35 tons of nonconserved air conditioning, was omitted. The records, however, helped greatly in establishing a list of water-using air-conditioning installations.

At the end of 1953, according to accumulated data, 12,100 tons of water-cooled air-conditioning was installed. About 6,000 tons of this total was

not equipped with water conservation equipment. Inasmuch as each ton of air conditioning uses about 1,200 gal on a hot day and takes about 2 gpm when operating, the size of the load is apparent. The 6,000 tons of nonconserved air conditioners required water at the rate of 18 mgd, and used more than 7 mil gal on a maximum day. Such demand on the system could not be ignored. Entire subdivisions were being developed with 3- or 5- ton air conditioners in each house and, obviously, the problem would rapidly get worse.

It was known that a number of cities had outlawed water-cooled air-conditioning systems unless water-recirculating equipment was installed and operated. Moreover, in Arkansas the General Waterworks Corp. had been granted an annual surcharge of $12.50 per ton for nonconserved units. The policy adopted by the St. Louis County Water Co. was to undertake to supply water for all demands, including water for cooling air-conditioning systems, made by customers and to seek a fair, equitable rate for water used for air conditioning during the summer season. Rate changes for a privately owned utility have to receive the approval of the Missouri Public Service Commission after a public hearing. A fair charge would be obtained only on development of a clear-cut case, for which facts and sound estimates would be necessary.

Reasons for Surcharge

An analysis of the air-conditioning accounts was made to see if there existed definite patterns which would support a demand charge or surcharge for nonconserved air-conditioning use. Residential accounts were inspected to find the ratio of summer to nonsummer consumption. These ratios averaged from 5½ to 7 times as much water in summer as in winter. Data for houses on each side of residences with air conditioning were then accumulated to provide a comparison of customers similar except for air conditioning. The ratio of summer to nonsummer use by residences without air conditioning averaged less than 1½:1 (*see* Table 1).

The pattern of use during the year before air-conditioning equipment was installed in small commercial establishments was compared with the use 1 year later. It was found that summer consumption averaged 6–10 times that of nonsummer. Before air conditioning was installed, the summer use had been less than twice that of nonsummer (Table 1). These surveys were positive evidence that air-conditioning customers had summer demands which, on the average, were many times greater than those made by other, comparable, customers.

If higher rates were to be charged, it would be necessary to develop and substantiate them. The first step was to find out what investment the water company had to make to supply customers possessing air conditioning. Because the territory was developing rapidly, there was no existing extra capacity that could furnish water to these new customers. Capacity to meet all additional demands had to be built at current inflated prices. A study indicated a cost of $722,000 for the purification and pumping plant, mains, storage, and other installations necessary to produce and deliver 1 mil gal on a maximum day, or 72.2 cents for each gallon. Assuming that 1 ton of air conditioning used 2 gpm and operated 10 hr on a hot day, 1,200

gal would be required. The water company cost for facilities to produce and deliver this amount would be 1,200 times 72.2 cents, or $866.40 per ton of air conditioning, a very high figure. The comparable capital investments of customer-provided water conservation equipment and water company-built facilities are:

1. Conservation equipment for a 3-ton unit costs $430; the cost of water company facilities is $2,580.

2. Conservation equipment for a 5-ton unit costs $600; the cost of water company facilities is $4,300.

3. Conservation equipment for a 10-ton unit costs $900; the cost of water company facilities is $8,600.

Operating costs also varied considerably because the water company had to purify raw water and pump it at 215 psi, whereas the customer merely had to recirculate the water with a small, low-head pump, force air through the cooling tower with a small fan, and add a little water to make up for evaporation.

Computing Surcharge Rate

The information concerning the cost of facilities to service 1 ton of air conditioning provided the basis for computing a demand or surcharge rate. Reasonable fixed charges of 12 per cent annually (covering return at 6 per cent, depreciation at 1½ per cent, property taxes at ½ per cent and income taxes at 4 per cent) on an investment of $866.40 would be $103.97 per year. It may also be assumed that water in the St. Louis area would be used for air conditioning during parts of 5 months each year with none being used in the remaining 7 months. The surcharge would cover the fixed charges on facilities provided, but not operated, during these months. Seven-twelfths of $103.97 is $60.65 per year, a proper surcharge above the regular charge for water consumed in 1 ton of nonconserved air conditioning. This surcharge is based on today's cost of construction.

The general water rates, however, were based on historical, not replace-

TABLE 1

Average Monthly Consumption

Season	Residential Consumption—*cu ft*			
	No Air Conditioning*	3-Ton Units	5-Ton Units	7½-Ton Units
Summer	1,928	10,724	12,441	15,163
Nonsummer	1,308	1,711	1,820	2,725
	Small Commercial Consumption—*cu ft*			
	Before Installation	3-Ton Units	5-Ton Units	7½-Ton Units
Summer	3,662	8,155	14,075	21,089
Nonsummer	1,927	808	2,078	3,651

* Adjacent to homes with air conditioning.

ment, cost. A case could be made that water rates for air conditioning should be similar to those for other uses. Such a computation was made, reflecting the air-conditioning load factor. In the St. Louis area, air conditioners operate approximately 1,000 hr per year. Assuming operation of 10 hr on a hot day, the annual use of water would be about 100 times that of the maximum day. The annual sales of water to all customers, however, were 223 times the maximum day's sales. Compared with all water uses, air-conditioning use had a load factor deficiency equal to 123 times the maximum day's use. For each ton of air-conditioning capacity, the deficiency would be 123 times 1,200 gal, or 147,600 gal per year. This deficiency was figured at a unit cost equal to the average revenue per 1,000 gal sold for all uses, minus the savings in power and chemical cost, as none of this water would actually be produced and delivered. On this basis, the surcharge would be $41.97 per year, about 66⅔ per cent of what it would be if based on present-day costs of facilities (see Table 2).

After this computation, an application filed on Aug. 6, 1954, for an annual surcharge of $40 per ton of nonconserved air conditioning, with all water consumption to be billed at the regular applicable rates, outlined the amount and basis of the charge, provided standards for measuring the capacity of air-conditioning units, and furnished definitions of conserved and nonconserved air conditioning. The application considered several ques-

TABLE 2

Development of Surcharge for Nonconserved Water-cooled Air-Conditioning Units

Air conditioner operation	1,000 hr per year at 2 gpm per ton
Max. day's use (10 hr times 2 gpm per ton)	1,200 gal/ton
Total annual use (1,000 hr times 2 gpm per ton)	120,000 gal/ton
Total annual use	100 times max. day's use
Total pumpage, max. day 1953	64 mil gal
Estimated total sales, max. day 1953	57.6 mil gal
Total sales, 1953	12,837.9 mil gal
Total annual sales	223 times max. day's sales
If air conditioning had average load factor, annual use would be:	
223 times 1,200 gal per ton	267,600 gal/ton
Estimated actual use	120,000 gal/ton
Deficiency in use of water	147,600 gal/ton
Average revenue per 1,000 gal sold, 1953 $\left(\frac{\$3,750,034}{12,837,899}\right)$	29.2¢
Revenue deficiency per ton of air conditioning (147.6 times 29.2¢)	$46.10
Credit for unused power and chemicals (147.6 times 2.8¢)	4.13
Net annual revenue deficiency per ton of air conditioning	$41.97

Annual air conditioning surcharge should be $41.97 per ton

TABLE 3

Annual Costs for Nonconserved and Conserved Units

Item	Air-Conditioning Equipment				
	2-ton	3-ton	5-ton	7½-ton	10-ton
Nonconserved units					
Annual quantity of water*—*cu ft*	32,000	48,000	80,000	120,000	160,000
Unit cost of water—¢/*100 cu ft*	2	19	18	18	17.5
Conserved units					
Annual quantity of water—*cu ft*	1,000	1,500	2,400	3,600	4,800
Unit cost of water—¢/*100 cu ft*	20	20	20	30	20
Electricity for fan and pump—*kwhr*	300	400	500	700	900
Unit cost of power—¢/*kwhr*	2	2	2	2	2
Annual Costs					
Nonconserved units					
Water	$ 64	$ 91	$144	$216	$280
Conserved units					
Water	$ 2	$ 3	$ 5	$ 8	$ 10
Power	6	8	10	14	18
Maintenance (3 per cent of cost)	9	13	18	23	27
Total	$ 17	$ 24	$ 33	$ 45	$ 55
Annual saving with conservation equipment	$ 47	$ 67	$111	$171	$225
Cost of installed conservation equipment	$300	$430	$600	$750	$900
Ratio of cost to annual saving†	6⅓:1	6⅓:1	5⅓:1	4⅓:1	4:1

* Water consumption assumed at 2 gpm/ton for nonconserved units; compressor operation assumed to be 1,000 hr per year.

† Indicates number of years it will take for annual saving to pay for cost of conservation equipment. (Expected life of conservation equipment is at least 10 years.)

tions that could be raised concerning the propriety of a surcharge for air-conditioning use of water. It had to be shown that such a surcharge, or demand charge, was being made because air-conditioning use was demonstrably different from other peak season water uses and was not unduly burdensome or discriminatory.

Patterns of Demand

A comparison was made of the patterns of water demand by air conditioning and lawn sprinkling, inasmuch as both impose large summer loads. On Jun. 30, 1954, there were 100,150 domestic customers (not including those in three systems obtaining water at wholesale). Had each of these sprinkled at the same time on a hot day at an average rate of 5 gpm, the demand would have exceeded 500,000 gpm, or a rate of 720 mgd for sprinkling only. The maximum hourly demand in 1954 for all uses was at the rate of 146 mgd from plant and distri-

TABLE 4

Air-Conditioning Costs With and Without Conservation

St. Louis County Water Rates*

Quantity *cu ft*	Cost *¢/100 cu ft*	Quantity *gal*	Cost *¢/100 gal*
First 1,200	30	8,940	
Next 12,100	20	90,145	2.68
Next 52,000	17	387,400	2.28
Over 65,300	13		1.75

Water Use Without Conservation

Rate *¢/100 gal*	Capacity of Air-Conditioning Unit					
	3 tons		5 tons		10 tons	
	Quantity *gal*	Cost *$*	Quantity *gal*	Cost *$*	Quantity *gal*	Cost *$*
2.68	90,145	24.16	90,145	24.16	90,145	24.16
2.28	359,855	82.05	387,400	88.33	387,400	88.33
1.75	—	—	272,455	47.68	1,022,455	178.93
Total	450,000†	106.21	750,000†	160.17	1,500,000†	291.42

Water Use With Conservation

Item						
Water‡	7,950	2.13	13,250	3.55	26,500	7.10
Electricity for pump and fan		6.75		9.30		13.30
Total cost		8.88		12.85		20.40
Annual net saving—$		97.33		147.32		271.02

Contractor's Charges for Conservation Equipment and Installation§—$

Item	Capacity of Air-Conditioning Unit		
	3 tons	5 tons	10 tons
Tower	195.00	243,00	367.00
Pump	76.00	82.00	101.00
Plumbing and electricity	75.00	100.00	125.00
Overhead and profit	86.00	106.00	148.00
Total	432.00	531.00	741.00
Approximate amortization period—*yr*	4¼	3½	2¾

* Incorporated areas.

† Average operation is 1,000 hr per season at 2.5 gpm/ton. This estimate of time in use is very conservative and is based on favorable conditions of installation and weather; unfavorable conditions can raise the figure 50–100 per cent.

‡ 2.65 gph/ton.

§ Figures supplied by a St. Louis firm.

bution storage. Considerably less than 20 per cent of the residential customers were sprinkling on the peak hour, showing that the diversity factor for lawn sprinkling is high.

By comparison, the diversity factor for air-conditioning use of water is low. On the hottest days, all air conditioning is in operation. At such times, units that cool offices and commercial space work the maximum number of hours, with few periods of compressor idleness, owing to excessive outside temperatures and comparatively high water temperatures. Residential air-conditioning systems function not only during office hours, but also throughout the evening sprinkling period and often through the night. Whereas 10–15 per cent of residential customers and a few commercial customers sprinkle on a given hot summer day, at least 95 per cent of all air-conditioning units will operate for maximum periods during all hot days. Some air-conditioning users pipe the waste water to lawn sprinklers, a procedure, however, that does not provide a diversity factor, because such sprinkling is done for maximum periods on every hot day. It was felt that the utilization of waste water for lawn sprinkling should not affect the imposition of a surcharge. The pattern of water use in nonconserved air-conditioning units was markedly different from the patterns of other uses. The designation of air-conditioning use for a surcharge was based on the pattern of use, not the end purpose.

TABLE 5

Estimated Future Water Demands for St. Louis County

Item	Year					
	1953	1954	1955	1956	1957	1958
Residential air-conditioning systems in United States[1]	100,000	220,000	460,000	820,000	1,360,000	2,060,000
Nonconcerved systems in St. Louis County[2]	900	1,980	4,140	7,380	12,250	18,550
Air conditioning in St. Louis County[3]—*tons*	4,500	9,900	20,700	36,900	61,250	92,750
Water for air conditioning on maximum day[4]—*mgd*	5.4	11.9	24.8	44.3	73.5	110.0
Water for all other uses on maximum day[5]—*mgd*	59	73	80	87	94	101
Total water requirements in St. Louis County[6]—*mgd*	64	85	105	131	168	211
Planned capacity[7]—*mgd*			103	136		
Additional capacity needed[8]—*mgd*			2	−5	32	75
Total customers[9]	102,000	111,000	121,000	131,000	141,000	151,000
Customers with nonconserved air conditioning[10]—*% of total*	0.9	1.8	3.4	5.6	8.7	12.3
Water used for nonconserved air conditioning[11]—*% of total*	8.5	14.0	23.5	33.8	43.7	52.2

[1] These figures are from the study released by the American Institute of Management (*1*).
[2] 0.9 per cent of total for the United States is considered as installed in St. Louis County.
[3] Estimated average of 5 tons for each unit.
[4] Water consumption on maximum day is 2 gpm/ton for 10 hr.
[5] Future annual growth is estimated at 9 per cent of 1954 requirements.
[6] Estimated maximum-day requirements for all uses.
[7] Increases in capacity for 1955–56 are in the process of realization.
[8] Additional plants and mains to produce another 75 mgd may be required by 1958.
[9] Actual customers on Jul. 31, 1953, and Jul. 31, 1954; estimated increase at 9 per cent of 1954 thereafter.
[10] Per cent of customers with nonconserved air conditioning is obtained by dividing the second item by the ninth.
[11] Per cent of water used for nonconserved air conditioning is obtained by dividing item four by item six.

Data were presented along with the application to show that the surcharge would not be burdensome to customers who would install water conservation equipment to escape the surcharge. They would actually save money at the regular rates (*see* Tables 3 and 4). Statistics from manufacturers and contractors aided in the preparation of exhibits to show that conservation equipment would sufficiently reduce water use and charges to pay the customers' added power costs and to amortize the costs of the conservation units in a period much shorter than their life. The installation of conservation equipment would also eliminate the need for replacing many old service pipes which were large enough to supply ordinary water demands but which could not handle a superimposition of 6–15 gpm.

Estimates were presented to show how the imposition of a surcharge on nonconserved air-conditioning systems would affect revenues. Because conservation equipment can be added nearly as easily and cheaply to existing units as if it had been installed initially, and because water use is reduced about 95 per cent by such apparatus, the water company expected a decrease, not an increase, in revenue. It was realized that the surcharge would price water from the utility system out of air-conditioning use. Although an increase in total water sales would be desirable, furnishing more peak load water at regular prices would be definitely unprofitable unless the customers without air conditioning were to have their bills increased.

Estimate of Future Load

Lacking at the time the application was filed was a realistic estimate of the eventual air-conditioning load. The only comprehensive study (*1*) of the air-conditioning industry and its growth, released by the American Institute of Management in September 1953, provided estimated figures of expected complete residential air-conditioning systems through 1958. The 100,000 units that were in operation in 1953 are expected to rise to 2,060,000 units in 1958. Statistics of the St. Louis County Water Co. for 1953–54 showed that approximately 0.9 per cent of the total units for the entire United States reported in the study were installed in St. Louis County in each of these years. The expected water load was projected for the years through 1958. The computed demands of 5.4 and 11.9 mil gal for air conditioning on the maximum days in 1953 and 1954, respectively, closely approximated water company estimates. It was expected that the maximum day would use 24 mil gal in 1955; 44 mil gal in 1956; 74 mil gal in 1957; and 110 mil gal in 1958. In 1958 only 12 per cent of the customers would have air-conditioning systems, but they would use 52 per cent of the maximum day's pumpage (Table 5).

At the hearing on Oct. 18, 1954, this additional information was presented to the Public Service Commission. Reiterating its position, the company stated that it was willing to provide water for any use, including air conditioning, but wanted each class of use to bear proper and equitable charges, which should be imposed during the coming year. It was emphasized that it was undesirable to build a lot of plant and system while facing the loss of the load that had required it because a satisfactory and cheaper way of providing air-conditioning cooling water—recirculation by the customer—was

available. On Apr. 18, 1955, the Public Service Commission issued the following order approving the $40 annual surcharge for nonconserved air conditioning:

That the St. Louis County Water Co. be and is hereby authorized to file within 10 days after the effective date of this order, a rate schedule whereby said company will be authorized to charge on and after May 1, 1957, for water furnished to its customers for use in nonconserved water-cooled air-conditioning equipment a rate of $40 per season per ton of rated refrigerating capacity, said charge to be in addition to charges payable under other applicable rates for water used, and to be applicable to all customers using nonconserved water-cooled air-conditioning equipment for comfort cooling.

The surcharge rates subsequently filed are presented in an appendix to this paper.

Reference

1. *Air-Conditioning Industry Appraisal.* American Institute of Management (Sep. 1953).

APPENDIX

Surcharge Rates for Nonconserved Air Conditioning

Applicability

These surcharge rates shall be applicable to "nonconserved" water-cooled air-conditioning units, as defined below, which are installed or operated for maintenance by heat removal of room or space temperatures which are not less than 60°F and which are operated in summer months for comfort cooling. The surcharges shall be in addition to charges at regular applicable rates . . . for water used by such units.

These surcharge rates shall not apply to air-conditioning units that have no water connections or are "conserved" units, as defined below.

Billing and Payment

a. The amount of any annual surcharge shall be billed after May 1 of each year, and shall be the entire annual surcharge based upon the capacity of "nonconserved" air-conditioning equipment installed prior to Jul. 1 of each year.

b. Partial-year surcharges for new equipment installed after Jul. 1 of any year shall be billed after the date the proper surcharge has been determined.

c. No surcharge shall be billed where "nonconserved" air-conditioning equipment is installed but has been physically disconnected from the building plumbing system. If, however, such equipment is reconnected and operated at any time before Sep. 30 of any year, the entire annual surcharge shall be billed and paid for that year.

d. The payment of surcharge bills shall be enforced the same as bills for other water service.

Rates

a. An annual surcharge of $40 per ton of rated refrigerating capacity, as defined below, of "nonconserved" water-cooled air-conditioning units shall be charged in addition to charges under other applicable rates of this tariff for water used.

b. One-fourth of the annual surcharge shall be charged for each new

unit installed between Sep. 1 and Sep. 30, one-half of the annual surcharge shall be charged for each new unit installed between Aug. 1 and Aug. 31, three-fourths of the annual surcharge shall be charged for each new unit installed between Jul. 1 and Jul. 31, of any year.

c. Where "nonconserved" air conditioning is converted to "conserved" air conditioning by the installation of necessary equipment and the revision of water connections, the annual surcharge shall be reduced by nine-tenths for conversion between Jun. 1 and Jun. 30, by one-half for conversion between Jul. 1 and Jul. 31, and by one-fourth for conversion between Aug. 1 and Aug. 31, of any year.

Notification Concerning Installation of 'Nonconserved' Units

Each customer installing a new "nonconserved" air-conditioning unit in his premises shall promptly notify the water company of the date of installation and shall furnish information from which the capacity rating of such unit may be computed.

Definition of Rated Refrigerating Capacity

The capacity of a unit in tons shall be the greatest of the following:

a. The manufacturer's rating in tons per 24 hr of equivalent ice-making capacity

b. The 24-hr Btu rating of heat removal capacity divided by 288,000

c. The horsepower rating of the motor driving the refrigerant compressor

d. Nine-tenths of the horsepower rating of a motor driving both compressor and fan

e. Where none of the above ratings is available, or where question arises as to the accuracy of any rating, the rating shall be determined by measurement of power input to the compressor motor, the rate of fuel consumption, or other suitable means.

Definition of 'Nonconserved' Water-cooled Air-Conditioning Units

A "nonconserved" unit shall be one:

a. Which uses water from the building plumbing system directly for cooling refrigerant, with discharge to waste or to lawn sprinklers or to any other place where the water is not cooled and reused for cooling the refrigerant, or

b. Which uses an average of more than 12 gal of water from the building plumbing system per hour per ton of cooling capacity when the unit is operating, or

c. Which has accompanying conservation equipment installed, but which has the piping so connected that a valve may be opened or other means are provided so that water may be taken from the building plumbing system to allow operation of the air conditioning unit when the conservation equipment is out of service.

Definition of 'Conserved' Water-cooled Air-Conditioning Units

A "conserved" unit shall be one:

a. Which is equipped with cooling tower, atmospheric condenser, spray pond, or other equipment which shall directly or indirectly cool refrigerant, and

b. Which can use water from the building plumbing system only for makeup water to replace

water lost by evaporation or by flushing of the equipment, and

c. Which uses an average of less than 12 gal of water from the building plumbing system per hour per ton of cooling capacity when the unit is operating, and

d. Which has no piping connection to allow operation of the air-conditioning unit by direct use of water from the building plumbing system either in conjunction with or in place of such cooling tower, atmospheric condenser, spray pond, or other recirculating and heat-exchanging equipment.

Rules and Regulations

The general rules and regulations set forth in this tariff shall govern the supply of service under this rate.

Dale LeRoy Maffitt
1892–1955

A gracious gentleman of the highest moral character.
A great credit to the water works industry.

Dale L. Maffitt, past-president of AWWA and general manager of the Des Moines, Iowa, Water Works, died of a stroke Oct. 26, after being in failing health for some time. He was 63. Born in Des Moines in 1892, and recipient of a B.S. degree from Drake University in 1914, he joined the Des Moines Water Works as assistant chemist upon graduation. He advanced to positions of successively greater importance and was named general manager in 1933.

An AWWA member since 1918, he was elected president in 1954. Previously he had served as chairman of the old Missouri Valley Section and twice as director for the Iowa Section, which gave him the Fuller Award in 1949. His extensive activities in the Association included chairmanship of the Water Resources Division, the former Finance and Accounting Division, the Committee on Public and Worker Relationships, the Committee on Pension and Retirement Plans, the Committee on Social Security Legislation, and the Fuller Award Society, as well as membership on many other committees.

An inspired leader in civic and Association affairs, his loss will be deeply felt by all who knew and worked with him and by those whom he served.

Water Main Cleaning

John G. Copley

A paper presented on Sep. 8, 1955, at the New York Section Meeting, Upper Saranac Lake, N.Y., by John G. Copley, Gen. Mgr., Elmira Water Board, Elmira, N.Y.

THE prime reason for the tremendous investment that has been made in water main installations now and in the past is to get the water supply from the point of production to the ultimate consumer.

Water distribution is essentially a transportation problem, and, in common with all other agencies established for the purpose of transportation, it has the same opponent—friction.

The dictionary defines friction as "a resistance to motion between two surfaces in contact." On the surface of the ground, wheels and bearings and lubrication are used to decrease this resistance to motion. In water mains more power is needed if frictional resistance increases, but the use of power can be conserved if there is a decrease in frictional resistance.

The above definition, of course, does not correctly describe the friction of water rubbing on pipe. Friction loss in a pipeline is actually a loss of energy, or a degradation of the available energy of the flowing stream of water into unavailable energy in the form of eddies and turbulence and heat. Pipe smoothness or roughness either decreases or increases this turbulence, and, hence, either decreases or increases internal eddy losses.

What makes a pipe smooth or rough? Even a freshly manufactured pipe has some roughness, but it is more or less the standard to work from. The flows in a new pipe can be figured and the size that will deliver the amount of water required can be determined. The trouble with pipe, as with suits and hats and shoes, is that it does not stay new.

Causes of Roughness

The effects of aging on pipe differ with the locality. One common cause of pipe roughness is corrosion, caused by electrochemical action.

In steel and occasionally in cast-iron lines a pitted condition develops naturally, causing increased turbulence and decreased flows. Pitting, however, is not as serious as is tuberculation, which is the accumulation of the products of corrosion on the inside of the pipeline. Tubercles often continue to grow and increase in number until much of the cross-section area of the line is lost to flow. In newer lines the tubercles often look like small brown plants springing from the inside of the pipeline where minute breaks in the lining have appeared.

In raw-water lines, the carrying capacity can be decreased by the collection of sedimentary deposits that settle to the bottom quarter and harden in place with the help of the products of corrosion. Also, chiefly in mains carrying raw or untreated water, there

is the problem of slime growths on the inside wall of the pipe. The continued collection of these growths can seriously cut the flow in a pipeline. Another problem is the accumulation of air in high points of the pipeline, cutting the effective cross section of the main and reducing the flow.

These are five reasons for the loss of carrying capacity of a water main. In New York state, however, the chief causes are tuberculation, sedimentation, and slime growth. All three of these can be corrected by pipe cleaning.

Procedure

In mains 8 in. and larger, the pipeline is cut in two places and a cleaning machine placed in one of the pieces of pipe removed. The pipe is then replaced with bolted sleeves. At the other opening, provision is made to dispose of the water that will be discharged. Usually the line is brought to the surface with a 45-deg bend and then sand bags are used to direct the water to sewer lines or creeks. Extensive planning is sometimes required to do this part of the job satisfactorily. In very large mains a temporary plug with 4-in. discharge valves can be used to help control flows and reduce the amount of water that will be discharged during the cleaning operation. The cleaning machine is then propelled through the pipeline by water pressure at a speed of about 3 mph, scraping clean the pipe walls as it progresses and flushing the waste material ahead of itself.

The operation is relatively easy and painless where transmission mains are concerned, but it becomes somewhat more complicated in distribution mains which serve many customers. It is usually advisable to do work in such areas at night, when customer use is at a minimum.

All services connected to the section of main to be cleaned should be shut off at the curb to help prevent waste material from clogging the small lines. In case such clogging does occur, the line can usually be cleared by a blast of air from a compressor applied at the house end of the service. It is always advisable to check the screens of all meters after completion of the cleaning process.

Following the discharge of the machine at the open end of the line, the line is flushed clear and the cut section of pipe is replaced with bolted sleeves.

Tests indicate that this type of cleaning process will restore carrying capacity to a point equal to that of a new line. Once the cleaning is done, however, the corrosion process resumes, and often at a faster pace than before, because of the uncoated pipe areas exposed by the removal of the tubercles. A more or less permanent restoration of carrying capacity may be achieved by following the cleaning operation with a lining operation. Through the use of automatic machinery, a cement-mortar coating or lining can be applied to the inside of an existing pipeline, providing a noncorrosive surface that will maintain flow characteristics for years.

One type of lining machine uses the centrifugal method of applying the mortar. The machine works backward, applying a predetermined thickness of mortar and then smoothing it with revolving trowels as the unit travels toward the opening in the pipeline. Operators control the machine and deliver the premixed mortar in lines of 24 in. and larger. An automatic machine with hose-delivered mortar is used with lines 20 in. and

16 in. in diameter. In the larger lines, tees, bends, and other fittings are hand lined and troweled to provide a completely unbroken, smooth conduit to carry water.

Another type of lining machine applies cement mortar pneumatically with revolving trowels to provide a smooth surface.

Water Treatment

By proper adjustment of the pH value in water treatment, corrosive action can be slowed down. Table 1 shows this relationship between pH value and carrying capacity.

TABLE 1

Relationship of pH to Carrying Capacity

pH	Loss in Capacity in 30 yr—*per cent*
8.0	30
7.5	35
7.0	45
6.5	60
6.0	80

In other words, a water adjusted from pH 6.5 to pH 7.5 will have 65 per cent of its carrying capacity left after 30 years instead of 40 per cent, or a difference of one-fourth the original capacity. Such a saving in carrying capacity loss would justify annual treatment costs of $800 for every $100,000 in main investment.

Slime growths on pipelines can be removed by the same cleaning process noted previously, but with a different type of cleaning machine that will protect the pipe lining.

Chlorine can also be used, but usually a high dosage is required for effective removal. A slime growth problem can be prevented from recurring by a moderate treatment of chlorine if the original accumulation is removed by machine cleaning.

Results in Elmira

One of the mains in the Elmira, N.Y., system has gone through almost all of the above-mentioned stages. It was a 24-in. cast-iron main 7,000 ft long, carrying raw water from the Chemung River pumping station to the coagulation and sedimentation basin at the filtration plant. This main was installed in 1911 and was 37 years old when the rehabilitation project was begun in 1948.

In March 1948, before the decision to line the 24-in. main, the two pumps at the pumping station produced the following flows, as registered by venturi meters: No. 1 unit had a flow of 6.87 mgd with a discharge head of 157 ft; No. 2 unit had a flow of 9.04 mgd, with a discharge head of 178 ft.

On Apr. 16 tests were again made on the No. 1 unit. The results showed a flow of 7 mgd, a head loss of 33.17 ft, and a *C* value of 79 (24-in. diameter).

Following the cleaning of the main, pumping tests were made with venturi meters on May 24. Unit No. 1 had a flow of 8.10 mgd and a discharge head of 139 ft; No. 3 unit had a flow of 12.10 mgd and a discharge head of 169 ft.

A check of the lined 24-in. main was made on Sep. 2, 1949, with pitometers. The test results for No. 1 unit showed a flow of 8.13 mgd, a head loss of 19.0 ft, and a *C* value of 124 (24-in. diameter). For the same period, by venturi measurement, No. 3 unit produced a flow of 12.10 mgd.

During the year following these tests, the capacity of the main began to decrease. Figures for October 1948 were compared with those for October

1949, showing a decrease in discharge head from 336,000 gph to 312,000 gph for No. 1 unit, and a decrease from 495,000 gph to 450,000 gph for No. 3 unit. The power consumed in 1948 had been 0.571 kw per million gallons. In 1949 it was 0.650 kw per million gallons, an increase of 13.8 per cent.

Two more tests were then made employing pitometers. On Nov. 22, 1949, No. 1 unit was tested as having a flow of 7.5 mgd, a head loss of 21.5 ft, a C value of 108 (24-in. diameter), and a discharge head of 140.7 ft. On Jan. 24, 1950, No. 3 unit had a flow of 10.8 mgd, a head loss of 46.36 ft, a C value of 102 (24-in. diameter), and a discharge head of 173 ft.

As the pitometer test suggested a growth on the inside of the main, it was treated with copper sulfate in high concentration for 8 hr and then flushed. No results were obtained.

On Mar. 23 the main was opened and the interior was found to have a coating of slime growth. The upper third of the pipe had a very thin coating estimated at $\frac{1}{32}$ in. to $\frac{1}{16}$ in. in thickness with deep brown or chocolate brown color. The material was soft, but hard to scrape clean. The lower two-thirds had the same type of coating, but it was somewhat thicker because of a large amount of entrapped silt, giving the bottom section a very light brown or gray color. Samples of material from both top and bottom of the pipe were obtained. Also a 4-in. square section was removed with coating intact. The cement lining was sound, smooth, and firmly bonded to pipe, although stained brown. The pipe under was clean and bright under removed section.

Microscopic examination of the scraped material disclosed a large amount of *Crenothrix*, or iron bacteria, and also some evidence of similar organisms. Inspection of the section under large magnifying glass disclosed the fuzzy or hairlike character of the slime growth.

As the copper sulfate treatment had apparently been ineffective, a heavy application of chlorine was used and allowed to remain in the line for 24 hr. As this application was no more effective than the copper sulfate, it was decided to clean the main by use of a rolled-edge scraper to prevent damage to the cement lining. This cleaning was completed in May 1950.

The discharge head on the pump dropped from 74 psi to 68 psi, a decrease of 6 per cent, and the capacity of the larger pump increased from 10.9 mgd to 12.1 mgd, or 11 per cent.

The prechlorination point for the raw water was relocated from the filtration plant to the pumping station and approximately 2 ppm chlorine was applied to the raw water entering this line. Since that time, the increased capacities resulting from the original lining process have been reasonably retained.

Other systems are also obtaining the same financial advantages and improved flow characteristics that accompany cleaning and lining of water mains. In 1945 Lewis B. Smith, superintendent of the Rochester, N.Y., water department, reported *(1)*:

> The city paid for cleaning and lining a total of $145,973.32. The leaks at the cast-iron joints where the lead had pushed out or the hubs had cracked had to be dug up and repaired and this work was done by city forces and added to the cost of reconditioning. The additional sum spent by the city amounted to $28,220, making a total cost of $174,193.32 for 38,131 ft, or $4.57 per foot.

After reconditioning, the 36-in. line tested to a *C* coefficient of 100. This is equivalent to a new 33-in. line having a *C* coefficient of 130. The cost of laying a new 33-in. line at that time would have been at least three times the total cost of reconditioning the old line and the time required would have been much longer. Because of the use of the reconditioned conduit it has not been necessary to purchase water from outside sources, so that the city has profited by saving both time and money.

David Auld, then with the Washington, D.C., Water Div., reported on the results achieved at his plant as follows (*2*):

Careful measurements of the flows and losses showed that, after lining, the 36-in. main had a coefficient in excess of 140, based on nominal diameter—twice that obtaining in portions of the line before work was started. The 24-in. line, which was cleaned but not lined, showed a coefficient of 121, which was an increase of more than 50 per cent. Translated into terms of usefulness, these mains are capable of carrying about twice as much water as formerly, with the same loss of head. The main which was lined may be expected to retain a capacity which closely approaches that which it had when laid in 1904.

Although the work described involved only a very small part of the total length of the lines supplying the critical area, the improvement was distinct. After cleaning and lining, the pressures available to the suction side of the high-service pumps at no time fell below 20 psi, whereas formerly they frequently fell to 15 psi. This improvement can be attributed entirely to the cleaning and lining operation. The 5-psi increase in suction pressure, while apparently small, served to increase the discharge of the largest pumping unit by 33 per cent. The benefit can be more fully appreciated when it is realized that consumptions in this area were about 20 per cent greater during the summer of 1944 than during the previous summer and, notwithstanding this greater load, the pressures were consistently better than formerly.

Conclusion

The rapid decrease in main carrying capacity which is affecting water works systems throughout the country is a problem that must be faced. The fact that three widely separated areas with very different problems have profited so greatly from cleaning and lining their water mains seems to indicate that methods are available to meet the challenge.

References

1. Smith, Lewis B. Reconditioning of the Rochester Conduit. *Jour. AWWA*, **38**:69 (Jan. 1946).
2. Auld, David. Getting Designed Capacity From Distribution Systems by Cleaning and Lining. *Jour. AWWA*, **37**:199 (Feb. 1945).

Exposure Tests on Three Types of Pipe

M. J. Shelton and Bert C. Wilkas

A paper presented on Jun. 16, 1955, at the Annual Conference, Chicago, Ill., by M. J. Shelton, Gen. Mgr. & Chief Engr., and Bert C. Wilkas, Constr. Engr.; both of the La Mesa, Lemon Grove & Spring Valley Irrigation Dist., La Mesa, Calif.

A recently published article concerning the effect of exposure to soils on the properties of asbestos-cement pipe (*1*) cast serious doubt on the durability of distribution mains made of this material. Because approximately half of the mains up to 12 in. in diameter being installed in the rapidly expanding La Mesa, Lemon Grove, and Spring Valley Irrigation Dist. are of this type, it became imperative that the subject should receive additional study. The urgency of such a study was further accelerated by the district's merger with another water district which will require installation of 50 miles of water mains within the next 8 months.

The district was fortunate enough to have installed in 1939, as a part of its distribution system, a test section consisting of 4-in. asbestos-cement pipe, 4-in. unlined cast-iron, and 4-in. asphalt-base mastic–coated * steel pipe. The San Diego Water Dept. and the Los Angeles Dept. of Water and Power also had test sections of asbestos-cement pipe of about the same age and they cooperated in this study. Specimens of pipe from all of the test sections were removed from the ground, examined, and subjected to internal hydrostatic bursting tests.

The results of the study, as described in this paper, are at variance with the findings reported in the Romanoff-Denison article (*1*). There was no evidence from which it could be concluded that the asbestos-cement pipe was being seriously softened by exposure to the soil under field conditions.

Description of Test Sites

The Los Angeles test section consists of 8-in. Class 200 asbestos-cement pipe which was installed on Torrance Boulevard near 209th Street on Aug. 2, 1940, and removed Dec. 6, 1954. The specimens had a cover of 34 in. in soil of 450–1,300 ohms/cm/sq cm resistivity.

There were two San Diego test sites. On James Street near Chatsworth, a section of 4-in. Class C asbestos-cement pipe was installed in 1937 and removed Nov. 15, 1954. The soil was a light clay adobe of 1,700 ohms/cm/sq cm resistivity and the depth of the pipe was 27 in. The natural ground conditions were always moist, but the pipe was located above the ground water table. The other section, on Dorcas Street near Morena Boulevard, was of 5-in. Class 200 asbestos-cement pipe installed in 1940 and removed in November 1954. The native soil, also used as a backfill material, was a

* The coating used for these tests was "Somastic," a product of Standard Oil Co. of California, San Francisco.

clayey sand with resistivity of 2,800 ohms/cm/sq cm. The depth of the pipe was 30 in. At this site also, the soil at the level of the pipe was always moist, but the pipe was above the ground water table.

A layout and profile of the district's test section are shown in Fig. 1. The section was located on Sweetwater Road, south of Ildica, in Spring Valley, at the end of an operating 4-in. cast-iron line which entered the test area from higher, drier ground with soil resistivity of approximately 1,500 ohms/cm/sq cm. The section consisted of 4-in. Class 250 cast-iron pipe, 4-in. Class 200 asbestos-cement pipe, and 4-in. asphalt-base mastic–coated steel pipe, all of which were installed in November 1939 and removed on Nov. 15, 1954. For the first 11 years of the test, the operating pressure was approximately 140 psi, but in 1950 it was reduced to 90 psi by the installation of a pressure regulator.

The test section was in an area near the lowest elevation of the distribution system, and the water table varied within a few feet above and below the level of the pipeline. The pH of the native soil in this area was between 7.4 and 8.0 and the moisture content varied from 17.4 per cent to 21.7 per cent along the test sections. The soil resistivity was 280–480 ohms/cm/sq cm. Because of road improvements that had been made, the pipeline had several layers of road mix in its 48–54 in. of cover. A sodium azide test in the area indicated that there were no

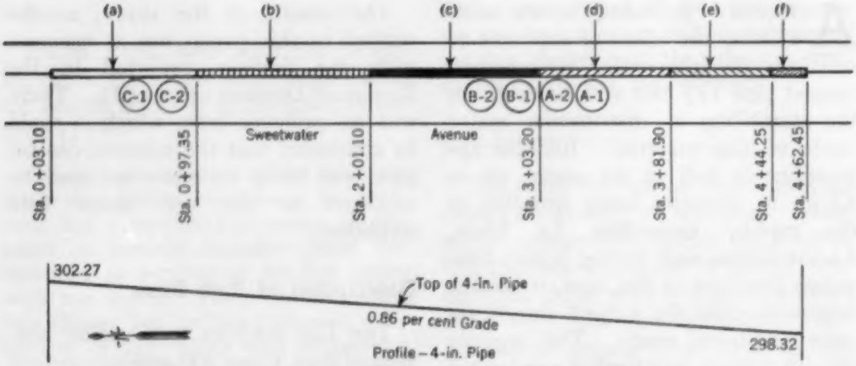


Fig. 1. Layout and Profile of La Mesa Test Section

The test section consisted of three types of pipe in sand or native soil backfill. The pipe and conditions in each case are as follows: (a) 94.25 ft of 4-in. cast-iron pipe, with a 6-in. bed and cover of sand backfill; (b) 103.85 ft of 4-in. Class 200 asbestos-cement pipe, in native soil; (c) 102 ft of 4-in. Class 250 cast-iron pipe, in native soil; (d) 78.7 ft of 4-in. asphalt-base mastic–coated steel pipe, weight 10.79 lb per foot, in native soil; (e) 62.35 ft of 4-in. asphalt-base mastic–coated steel pipe, weight 7.63 lb per foot, in native soil; (f) 18.20 ft of 4-in. Class 250 cast-iron pipe in native soil. The lettered symbols along the pipe sections refer to the keyed samples in the photographs.

anaerobic or aerobic bacteria present. *In general, conditions at the test site were very conducive to severe corrosion,* but there had been no leak experience in the 15 years the pipe had been in service. Cross sections at various stations in the test area are shown in Fig. 2 and 3.

Elements Affecting Corrosivity

The pipe arrangement within the district test area was as follows: [1] cast iron with sand backfill; [2] asbestos-cement in native adobe soil; [3] cast iron in native adobe soil; and [4] asphalt mastic–coated steel in native adobe soil. Their relative positions along the line are important to the extent that the various sections affect or are affected by long-line currents.* The most likely possibilities of flow of long-line currents in this pipeline were off the pipe in the low, wet test area and onto the pipe in the more highly resistant, dry area north of the test section. The asbestos-cement section would disrupt this current flow to the cast-iron section in native soil, *the cast-iron section with sand backfill was not protected from these long-line currents.* In fact, the asbestos-cement section may have caused an abnormal amount of current to leave these sections. In the lowest areas, cast-iron sections with sand backfill were not insulated by the asbestos-cement section. It is very probable that the test section in native soil would have suffered more corrosion if it had not been isolated from the more highly resistant soil portion of the line. The effect that the asbestos-cement section had on the corrosion rate of the cast iron with sand backfill was dependent upon the insulation value of the sand.

* "Long-line" current is current that flows through the earth from an anodic to a cathodic area and returns along an underground metallic structure.

The sand resistivity ranged from 3,200 to 5,500 ohms/cm/sq cm. This is much higher than that of the adjacent soil, but also much lower than the normal resistivity of backfill sand. Unfortunately, the resistivity of the sand when it was installed is not known. It is quite safe to estimate that its resistivity has decreased from one-third to one-half of its original value. While its insulation value decreases considerably with time, its second function, that of protecting the pipe from soil stresses, remains of consistent value. The corrosion resistance of the sand backfill is highly dependent upon the quality of the sand used, as well as the care exercised in installing it uniformly and cleanly about the pipe.

Hydrostatic Pressure Test

The equipment used for the field hydrostatic testing of the three types of pipe was borrowed from the Cast Iron Pipe Research Assn. and is shown in Fig. 4. Its essential components include: [1] two steel caps with external expansion rubbers for closing the ends of the section under test; [2] two steel plates held by two threaded rods on the outside of the steel caps and snugged up by nuts to prevent the caps from blowing off of the ends of the pipe; [3] a hand pump; [4] a Bourdon type test gage. The pipe was filled with water which was pumped through an outlet in the top of one of the caps until there was no evidence of entrapped air. As the gage began to indicate increasing pressure, the pumping operation proceeded at approximately a uniform rate while the

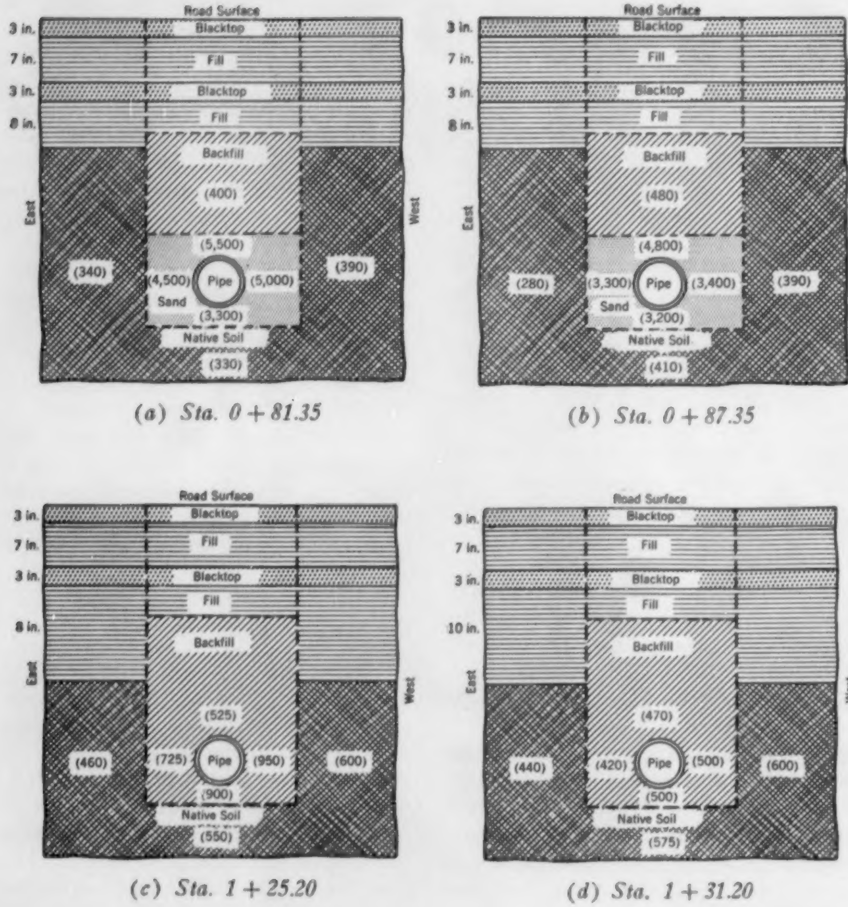
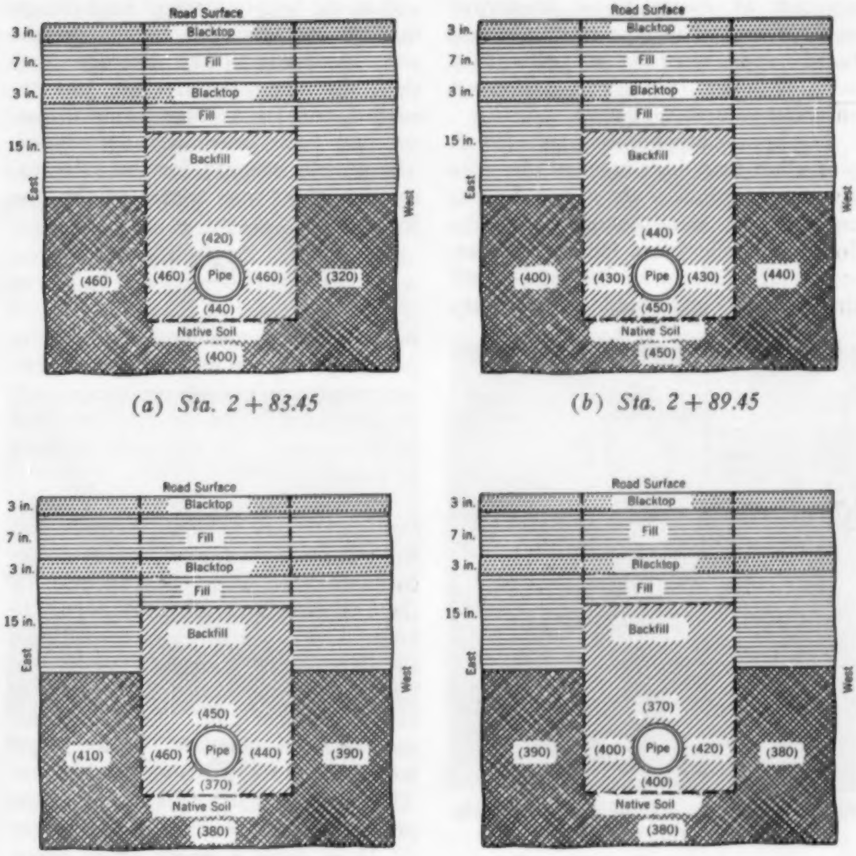


Fig. 2. Cross Sections of La Mesa Test Site

Pipe specifications and soil conditions at each station are as follows: (a) 4-in. Class 250 cast-iron pipe, pH of 5.7–8.4 in sand backfill, pH of 8.0 in native soil; (b) 4-in. Class 250 cast-iron pipe, pH of 7.9–8.8 in sand backfill, pH of 7.6 in native soil, moisture content of 17.4 per cent in native soil; (c) 4-in. Class 200 asbestos-cement pipe, pH of 7.4–8.0 in backfill and native soil; (d) 4-in. Class 200 asbestos-cement pipe, pH of 7.8 in backfill and native soil. Each section had a cover of 48 in. The water level at all stations was 1 in. below bottom of pipe. Figures in parentheses indicate resistivity measurement at that point.



(*a*) *Sta. 2 + 83.45* (*b*) *Sta. 2 + 89.45*

(*c*) *Sta. 2 + 93.45* (*d*) *Sta. 2 + 99.45*

Fig. 3. Cross Sections of La Mesa Test Site

Pipe specifications and soil conditions at each station are as follows: (a) 4-in. Class 250 cast-iron pipe, pH of 7.4 in backfill and native soil; (b) 4-in. Class 250 cast-iron pipe, pH of 7.4–7.9 in backfill and native soil; (c) 4-in. asphalt mastic–coated steel, pH of 7.4–7.6 in backfill and native soil; (d) 4-in. asphalt mastic–coated steel, pH of 7.4 in backfill and native soil, moisture content above water line 21.7 per cent. Each section had a cover of 54 in. The water level at all stations was 1 in. below bottom of pipe. Figures in parentheses indicate resistivity measurement at that point.

gage pressure was called out by the observer at every 50-psi increment until failure. The type of failure was noted and recorded. Testing of asbestos-cement pipe was performed on water-saturated samples.

The hydrostatic bursting tests for all pipe other than 4-in. nominal diameter and some sections of the 4-in. asbestos-cement pipe were conducted at the Johns-Manville Corp. factory in Watson, Calif. Except for the hand pump, the Bourdon gage, and the auxiliary

Fig. 4. Equipment Used for Hydrostatic Testing in the Field

This equipment was used for testing all three types of pipe.

hydraulic piping, the equipment was then being used by the factory for testing new sections of pipe. This equipment employs internal self-sealing rubber cups which close off the pipe at approximately 2 in. from the end. After the pipe was filled with water, entrapped air was bled off through a valve. Pressure was applied by a high-pressure hand pump at a constantly increasing rate of approximately 5 psi per second until failure.

The test equipment both in the field and at the factory were of such design that no end restraint existed on the test specimens. The average wall thickness along the fracture was recorded, and the average inside diameter had been previously determined. The tensile strength for the asbestos-cement pipe was computed by the formula:

$$f = P\,\frac{(d + 1.7t)}{2t}$$

in which f is the tensile stress in pounds per square inch; P is the bursting pressure in pounds per square inch at failure; d is the internal diameter in inches; and t is the wall thickness in inches.

The cast iron and steel pipe specimens were cut to approximately 5-ft lengths for hydrostatic testing in accordance with a practice adopted by the Cast Iron Pipe Research Assn. In order to attain a comparable test, two specimens, each approximately 5 ft in length were cut from every section of asbestos-cement pipe. Two additional specimens of standard 12-in. length were needed for a 3-edge bearing test. This usually left for hydrostatic-pressure tests a section of pipe about 12–15 in. long, a length which corresponded approximately to those used in the tests reported by Romanoff and Denison (*1*). The location of cuts was carefully selected so that sections appearing to be damaged by handling of the pipe would not be included. This resulted in some reduction of the length of specimens intended to be 5 ft.

Asphalt Mastic-coated Steel Pipe

The steel pipe was imbedded in natural clay adobe soil which was at all times in a saturated or near-

saturated condition. It will be noted from Fig. 1 that the steel pipe was taken from the lowest elevation of any of the test samples removed.

In the district test section, 4-in. steel pipe of ¼-in. wall thickness was protected with a ½-in. thickness of exterior asphalt mastic coating. No interior protective coating had been applied. Sections of the coated pipe before testing are shown in Fig. 5. When a 14-ft section of this pipe was removed from the trench which had been backfilled with the native adobe materials, the exterior coating appeared to be in perfect condition. After removal of the asphalt mastic coating, the exterior steel surface, shown in Fig. 6, was found to be entirely free of rust. There was, however, tuberculation on the interior of the pipe, as shown in Fig. 7.

Two 5-ft sections of this pipe were cut from the 14-ft length. They were provided with welded caps and tested hydrostatically in the manner previously described, except that it was not necessary to use expansion rubbers for sealing off the ends of the sections. Both specimens withstood an internal test pressure of more than 5,000 psi, the capacity of the field testing apparatus, without failure.

Because asphalt mastic–coated steel pipe is expensive and difficult to install, the district does not consider it to be a competitor for either asbestos-cement or cast-iron pipe.

Fig. 5. Asphalt Mastic–coated Steel Pipe Before Testing

When removed from the ground, this pipe had been in service for 15 years.

Fig. 6. Asphalt Mastic–coated Steel Pipe After Testing

The exterior steel surface was entirely free of rust.

Cast-Iron Pipe

The native soil, which is a gray adobe, was used as backfill surrounding one section of the cast-iron pipe. The other section removed from the ground had been placed in a backfill of coarse sand with an average thickness of 6 in. on each side, top, and bottom. The native adobe was used in the trench above the sand.

The two sections of cast iron pipe removed were 18-ft lengths of 4-in. Class 250 unlined deLavaud pipe. Figure 8 shows sections of cast iron pipe before testing. The pipe that had been in the adobe backfill was severely graphitized in localized areas, and one

spot of graphitization had penetrated the entire wall thickness of the pipe. The section embedded in the sand backfill material was also severely corroded, but the corrosion was more extensive and uniform. There were several pits, but no instances of complete penetration through the wall. As shown in Fig. 6, the interior tuberculation in sections of cast-iron pipe was approximately the same as for the steel pipe.

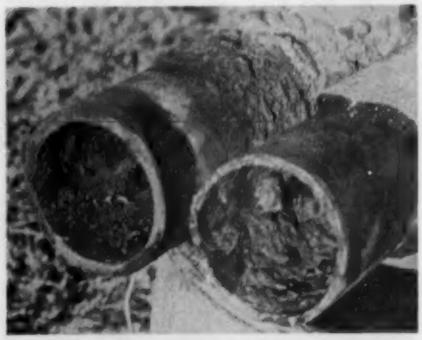


Fig. 7. Tuberculation in Two Types of Pipe

The unlined cast-iron pipe is on the left, the asphalt-base mastic–coated steel pipe is on the right. Interior tuberculation was approximately the same for both pipes.

Two 5-ft test specimens were prepared from the 18-ft lengths removed from the trench backfilled with the native soil. The specimens were cut to length in the machine shop with a power saw. Care was taken to prevent knocking off the soil adhering to the pipe except as required for cutting the specimens and placing them in the testing machine. One of the specimens failed by a longitudinal crack. The other failed at a spot of graphitization which had penetrated the entire wall thickness of the pipe. This carbon plug blew out, forming a hole approximately $\frac{1}{2}$ in. in diameter. The other specimen did not have any spots of graphitization which penetrated the entire wall thickness, the deepest pit being 0.268 in. The maximum test pressures attained are shown in Table 1.

Also prepared for testing were two 5-ft specimens from the length of pipe removed from the sand backfill. The excavation revealed that, 15 years ago, when the sand backfill was placed in the trench and around the pipe, at least two rather large pieces of adobe soil became mixed in with the backfill material. A section of approximately 16 ft, containing a bell joint, broke in two while in the hands of the workmen after it had been cut out of the line and was being lifted up to be placed on the side of the trench. A close examination showed that the bottom third of the spigot end, which had been resting on native adobe soil without any sand protection, had been graphitized completely through. This section of pipe was not used in the preparation of the 5-ft test lengths. When one end of a specimen was cleaned prior to being placed in the testing apparatus, a large clod of adobe was found adhering to the pipe under the sand. Removal of this clod exposed a large corroded pit approximately 2 in. in diameter and 0.267-in. deep. This specimen failed by a longitudinal crack passing though the deep pit. The other specimen also failed by a longitudinal crack. The maximum test pressures sustained are shown in Table 1. Sections of cast iron pipe after testing are shown in Fig. 9.

It should be pointed out that the pipe was originally laid as a test section using a district crew and following field procedures. It can be reasonably assumed, therefore, that the foreman was aware of the conditions and had carefully instructed his workmen that the sand backfill adjacent to the pipe should not become contaminated with the native adobe materials. Nevertheless, even on this single length of cast-iron pipe, which had been purposely laid in sand backfill for experimental reasons, there were two instances of serious contamination due to the human element. Under the circumstances, it would appear reasonable to doubt the practical possibility of installing any appreciable quantity of pipe by standard procedures of installation without such contamination. Even a very small piece of adobe or other material of low resistance would seem to cause damage.

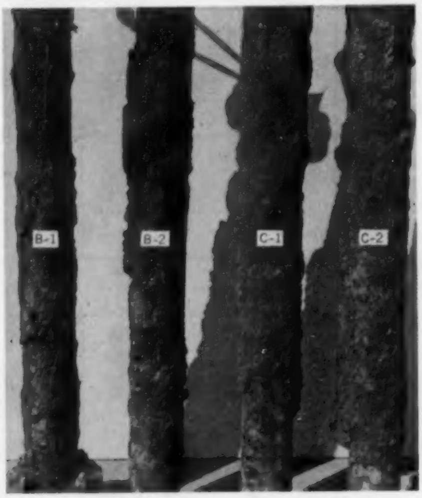


Fig. 8. Cast-Iron Pipe Samples Before Testing

The two samples on the left were removed from native adobe backfill. The two on the right, from sand backfill.

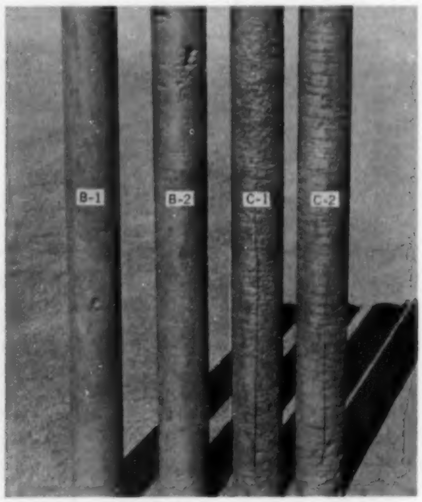


Fig. 9. Cast-Iron Pipe Samples After Testing and Sand Blasting

The pipes are arranged in the same order as in Fig. 8.

Asbestos-Cement Pipe

Two 13-ft lengths of 4-in. Class 200 asbestos-cement pipe were removed from the district test section. The pipe appeared to be sound on both the outside and the inside. The collars also were in good condition and attempts to remove them by jacking failed. It was necessary to use a chisel and hammer to break the collars.

For field hydrostatic testing, one of the 13-ft lengths was cut into two lengths of 4 ft 8 in. each and one length of 15 in. Two 12-in. lengths cut were cut for 3-edge bearing tests. The other 13-ft length was shipped to the factory at Watson where it was cut for hydrostatic testing and 3-edge

TABLE 1

Hydrostatic and Crushing Test Results on Steel, Cast-Iron, and Asbestos-Cement Pipe

Exposure Time *yr*	Backfill	Pipe ID *in.*	Class	Specimen Length *in.*	Hydrostatic Test: Bursting Pressure *psi*	Hydrostatic Test: Tensile Strength *psi*: Exposed	Hydrostatic Test: Tensile Strength *psi*: Unexposed	Crushing Test: Modulus of Rupture *psi*: Exposed	Crushing Test: Modulus of Rupture *psi*: Unexposed
La Mesa Steel Pipe									
15.0	adobe	4		60	5,000+*				
15.0	adobe	4		60	5,000+*				
La Mesa Cast-Iron Pipe									
15.0	adobe	4	250	60	1,625†				
15.0	adobe	4	250	60	1,900				
15.0	sand	4	250	60	2,300				
15.0	sand	4	250	60	2,550				
La Mesa Asbestos-Cement Pipe									
15.0	adobe (all specimens)	4	200	56	1,275	5,300			
15.0		4	200	56	850	3,860			
15.0		4	200	54	1,900	6,160			
15.0		4	200	54	1,770	5,360			
15.0		4	200	15	1,200	5,010			
15.0		4	200	15	1,390	5,710			
15.0		4	200	12				9,300	
15.0		4	200	12				9,700	
15.0		4	200	12				8,730	
15.0		4	200	12				9,850	
James Street, San Diego, Asbestos-Cement Pipe									
17.0	adobe (all specimens)	4	C‡	52	650	2,860			
17.0		4	C‡	52	825	3,500			
17.0		4	C‡	43	670	2,840			
17.0		4	C‡	43	450	2,150			
17.0		4	C‡	15	775	3,410			
17.0		4	C‡	12				5,060	
17.0		4	C‡	12				4,630	
17.0		4	C‡	12				5,980	
17.0		4	C‡	12				5,610	

* There was no failure.
† Failed through point of complete graphitization.
‡ Hydrostatically tested in factory to 260 psi before exposure.

TABLE 1 (contd.)—*Hydrostatic and Crushing Test Results*

Exposure Time *yr*	Backfill	Pipe ID *in.*	Class	Specimen Length *in.*	Hydrostatic Test: Bursting Pressure *psi*	Hydrostatic Test: Tensile Strength *psi* Exposed	Hydrostatic Test: Tensile Strength *psi* Unexposed	Crushing Test: Modulus of Rupture *psi* Exposed	Crushing Test: Modulus of Rupture *psi* Unexposed
Dorcas Street, San Diego, Asbestos-Cement Pipe									
14.0	clayey sand	5	200	48	1,450	5,660			
14.0	(all	5	200	48	1,450	5,590			
14.0	speci-	5	200	48	1,170	4,820			
14.0	mens)	5	200	48	1,390	5,680			
14.0		5	200	15	1,400	5,550			
14.0		5	200	13	1,270	5,400			
14.0		5	200	15	1,170	5,350			
14.0		5	200	12				7,780	
14.0		5	200	12				7,150	
14.0		5	200	12				7,090	
14.0		5	200	12				8,040	
Los Angeles Asbestos-Cement Pipe									
14.7	clay adobe	8	200	54	1,100	5,190	5,190§		
14.7	(all	8	200	53	1,070	5,060	5,190§		
14.7	speci-	8	200	53	1,160	5,370	5,190§		
14.7	mens)	8	200	53	1,240	5,870	5,190§		
14.7		8	200	15	1,210	5,760	5,190§		
14.7		8	200	15	1,100	5,310	5,190§		
14.7		8	200	12				10,410	9,300‖
14.7		8	200	12				9,750	9,300‖
14.7		8	200	12				9,180	9,300‖
14.7		8	200	12				10,040	9,300‖

§ An average value of four tests.
‖ An average value of eight tests.

bearing tests in approximately the same lengths. The results of these tests are shown in Table 1.

One 13-ft length and one 10-ft length of 4-in. Class C asbestos-cement pipe were removed from the San Diego test section. This pipe was clearly marked "Class C Tested at 260" and had been formed by the old manufacturing process, using relatively low pressures and water-curing. Present manufacturing practice provides high forming pressure (which results in a high density of the pipe) and steam curing. The San Diego pipe, installed in 1937, was imbedded in the native clay adobe soil of the area. There has been no leak experience while this was in service.

The outside appearance of this pipe was good, the only observed defect being a chipped section of approximately ½-in. thick and 2-in. square at one of the machined ends. The chip

was still in place under one of the collars. It is considered possible that the damage may have occurred when spacing the pipe lengths at installation. The interior of the pipe appeared to be somewhat softened, and the cementing material seemed to have disappeared from the extreme interior layer of the pipe. A cross section of the pipe showed a brownish stain to a depth of approximately one-half of the wall thickness at the machined section of the pipe.

For field hydrostatic testing, the 13-ft length of this pipe was cut into two lengths of 4 ft 6 in. each and one length of 15 in. Two 12-in. lengths were cut for a 3-edge bearing test. The 10-ft length of this pipe was cut for hydrostatic testing at the Watson factory into two lengths of 3 ft 7 in. each, and two additional 12-in. lengths were cut for a 3-edge bearing test. The results of the tests are shown in Table 1.

Two 13-ft lengths of 5-in. Class 200 asbestos-cement pipe were removed from the San Diego test section. The native clayey sand material had been used for backfill around the pipe and there had been no leak experience during the entire period of service of this pipe. The appearance of the pipe on removal was good both inside and outside. There was no evidence of deterioration.

Since the field equipment could not be adapted for testing 5-in. pipe, both lengths were shipped to the Watson factory for testing. For hydrostatic testing, specimens were cut as follows: four lengths of 4 ft each, two lengths of 15 in. each, and one length of 13 in. Four 12-in. specimens were cut for 3-edge bearing tests. The results of the tests are shown in Table 1.

Two 13-ft lengths of 8-in. Class 200 pipe were removed from the Los Angeles test site. On both the inside and outside they appeared sound. The native Montezuma clay adobe was used for the backfill around the pipe, and there had been no leak experience during the entire period that this pipe was in service. Specimens were cut for hydrostatic pressure testing in lengths as follows: four specimens ranging in length from 53 to 54 in. each and two lengths of 15 in. each. Four 12-in. specimens were cut for 3-edge bearing tests. The results of the tests are shown in Table 1.

Comparison of Test Results

The results of the district's test on asbestos-cement pipe have been compared with the results reported by Romanoff and Denison in the following respects: [1] softening of the surface as indicated by scratch tests; [2] tensile strength as determined from bursting tests; and [3] modulus of rupture as determined from crushing tests.

Scratch Tests

Romanoff and Denison, in reporting the method of measuring the softening of surface layers of exposed specimens, stated that:

> Staves were cut from the specimens, 4 in. along the length of the pipe and 2 in. in width. A stave of an exposed specimen was mounted in a precision lathe, and the surface layers, which had been softened by contact with the soil, were removed by grinding under carefully controlled conditions. The grinding operation was continued until the measured hardness was equal to that of unexposed reference asbestos-cement pipe. The thickness of the softened layer was then taken as the difference in thickness between the original and residual wall, as

measured with a micrometer, or by recording the movement of the graduated compound cross-feed of the lathe. In measuring the hardness of the specimen, a cut was made with a tool so designed that the width of the cut varied with the applied load and hardness according to the formula:

$$\text{Hardness number} = \frac{\text{Applied load (g)} \times 1{,}000}{\text{Width of cut (mm)} \times 0.1}.$$

The cutting tool referred to in the above quotation was borrowed for use on similar tests of specimens included in this study. Although many man-days were spent in attempting to develop a technique for conducting this test, the results were so erratic, even on the same stave, that no conclusions could be drawn. Because of the nonhomogeneity of the material, the width of cut was extremely variable.

Tensile Strength

In the investigation covered by this paper, hydrostatic bursting tests were conducted on 24 individual specimens. The results are shown in Table 1. The tensile strengths computed for La Mesa 4-in. pipe ranged from 3,860 psi to 6,160 psi, with an average of 5,230 psi; those for San Diego 4-in. Class C pipe ranged from 2,150 psi to 3,500 psi, with an average of 2,950 psi; those for San Diego 5-in. pipe ranged from 4,820 psi to 5,680 psi, with an average of 5,440 psi; and those for Los Angeles 8-in. pipe ranged from 5,060 psi to 5,870 psi, with an average of 5,430 psi.

When the 8-in. Los Angeles pipe was purchased, it was the owner's specification requirement that there be factory hydrostatic and crushing tests of pipe from each batch which was fabricated to fill the order. One out of every 100 lengths of manufactured pipe was tested to ultimate hydrostatic bursting pressure. Four hydrostatic tests were made with a range of tensile strength from 4,930 psi to 5,500 psi with an average of 5,190 psi. The average tensile strength of the pipe after 15 yr exposure was 4.6 per cent higher than that of the unexposed pipe tested at the factory.

There were no ultimate hydrostatic or crushing tests made of the unexposed pipe placed in service in the other test sites. It is not known whether it may be correctly assumed that all sizes of Class 200 pipe manufactured at approximately the same time as the 8-in pipe had the same tensile strength immediately after manufacture, but it would appear to be a reasonable assumption, especially in view of the uniformity of tensile strengths of the exposed pipe from the three test areas of Class 200 pipe. The average of tensile tests on the exposed La Mesa 4-in. pipe was 5,230 psi—260 psi less than that of the Los Angeles 8-in. pipe. The average of tensile tests on the exposed San Diego 5-in. pipe was 5,440 psi—10 psi more than that of the exposed Los Angeles 8-in. pipe.

The San Diego 4-in. Class C pipe, originally tested at 260 psi in the factory, had an average tensile strength of 2,950 psi after 17 years of exposure. Because this was an inferior type of water-cured pipe, there is no basis for comparison with other specimens.

Modulus of Rupture

In the investigation covered by this paper, 3-edge bearing tests were conducted on sixteen individual specimens. The results are shown in Table 1.

The modulus of rupture was computed by the formula

$$f = \frac{0.9\ P(d+t)}{Lt^2}$$

in which f is the modulus of rupture in pounds per square inch, P is the failure-producing load in pounds, d is the internal diameter in inches, t is the wall thickness in inches, and L is the length in inches. The modulus of rupture computed for La Mesa 4-in. pipe ranged from 8,730 psi to 9,850 psi, with an average of 9,400 psi; that for San Diego 4-in. Class C pipe ranged from 4,630 psi to 5,980 psi, with an average of 5,320 psi; that for San Diego 5-in. pipe ranged from 7,090 psi to 8,040 psi with an average of 7,520 psi; and that for Los Angeles 8-in. pipe ranged from 9,160 psi to 10,410 psi, with an average of 9,840 psi.

At the time of purchase of the 8-in. Los Angeles pipe, eight specimens from the batch fabricated to fill the order were crushed to failure. The range of modulus of rupture was from 8,450 psi to 9,850 psi, with an average of 9,300 psi. The average modulus of rupture of the exposed 8-in. Los Angeles pipe was 5.8 per cent higher than that of the unexposed pipe tested at the factory. No crushing tests were conducted on unexposed specimens of pipe installed at the other test sites or for any shorter period of exposure.

Resistivity Map

Early in this investigation the district decided to develop and maintain a complete resistivity map based on a four-division, color-code system. Each color represented a certain range of resistivities and designated the type of pipe or backfill recommended for the area. The San Diego Gas and Electric Co. cooperates with the district in the mutual exchange of resistivity information based on tests in the area. This has resulted in a greater coverage by tests, which is very helpful at this stage in the development of a resistivity map.

As soil tests were made, a separate card file was maintained which included all of the resistivities, as well as other useful design information that was noted by the field man making the readings. All this information is reviewed whenever a new pipeline is considered.

Resistivity readings are obtained approximately every 1,000 ft throughout the entire district. Many of the readings are taken when the district or other agencies have open ditches in the area. Other readings are taken by boring down to the approximate pipe depth and measuring the soil resistivity. All readings are taken by the single-probe method and corrected to their true value before being posted. Figure 10 shows the relationship between single-probe and decimeter cubical readings.

The single-probe instrument used in the field work consists of a specially calibrated ohmmeter used in conjunction with a 4-ft steel tube which is inserted into the ground to the pipe depth. The soil resistivity is measured between a brass collar on the end of the steel tube and a stainless-steel tip insulated from the tube and collar by a ½-in.-long bushing. The test leads contact the tip and collar internally and extend up through the steel tube. In hard soil it is necessary to bore a hole to the proper depth before the probe can be inserted. In all cases the immediate test area of 4–5 in. around the tip is saturated with distilled water.

This test provided much useful information for the development of the area resistivity maps. Around the test pipe seven or eight soil resistance measurements and soil samples were

taken, as shown on Fig. 2. The resistivities were originally taken in the field with a single-probe instrument and later the identical samples were checked in the laboratory with a decimeter cubical. The results of these two methods agreed closely at resistivities below 3,000 ohm/cm/sq cm, but became poorer at high values. This has been particularly noticeable on coarse solids or sand and is primarily due to the impossibility of properly wetting the soil when testing a sample in the field. When the same sample was removed from the trench and checked in the laboratory, it was possible to saturate the sample properly in the cubical. In both cases, distilled water was used as the wetting agent.

Although sufficient samples were taken for complete chemical analysis of all test sections, these analyses were omitted from the study. According to H. H. Uhlig (*2*), the effect of variation of pH of water on corrosion of iron is negligible at 22°C for a pH range from 4.4 to 9.5 and at 40°C for a pH range from 4.5 to 8.4. A determination was made of the pH at many locations along the test sections. The pH of the native soil varied from 7.4 to 8.0. No significant conclusions could be drawn from the pH readings.

The soil resistivity about the pipe sections backfilled with native soil was the same in the trench a distance of 4 in. from the pipe as it was outside the original trench 12 in. from the pipe, being in all cases between 280 and 480 ohms/cm/sq cm. Along the cast-iron ctions with sand backfill, the resistivity of the native soil in the area was the same as that for the other test sections. The resistivity of the sand was between 3,200 and 5,500 ohms/cm/sq cm by the cubical method of resistivity measurement. Although no original resistivity was recorded on this sand, the normal backfill sand in this area has a resistivity of at least 10,000 ohms/cm/sq cm. From this it appears that the resistivity decreased to approximately $\frac{1}{2}$ or $\frac{1}{3}$ its original value. The sand did accomplish the job of somewhat uniformly distributing the corrosion and thereby extending the life of the pipe, but the corrosion rate was still very severe and

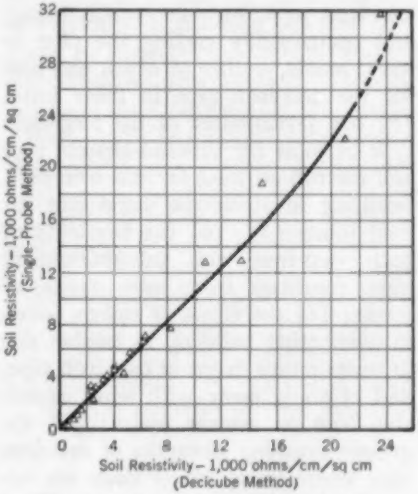


Fig. 10. Comparison of Resistivity Readings

Readings derived from the two methods agreed very closely at resistivities below 3,000 ohms/cm/sq cm.

could not normally be tolerated. The cast iron sections without sand backfill suffered much more localized attack and would have had approximately one-third less life than the sand backfill specimens.

Other Considerations

There are factors other than corrosion resistance which must be considered in pipe selection.

Pipeline costs are, of course, always an important consideration in selec-

tion of pipe. In the district, the purchase price of cast-iron and asbestos-cement pipe has been nearly the same recently. Actual selection is based on other considerations such as: [1] the greater resistance to corrosion of asbestos-cement pipe; [2] the cost of placing sand backfill for cast iron; [3] the higher crushing and tensile strengths of cast-iron pipe; [4] the recognition of new improvements in cast-iron pipe, such as cement lining, and centrifugally casting the pipe in metal molds, neither of which was true for the cast-iron pipe in these tests; [5] the development of the ring-tight type of joint for asbestos-cement pipe and the roll-on joint for cast-iron pipe, resulting in about the same cost for field joints (*5*); [6] the flexibility of both cast-iron and asbestos-cement pipe resulting from new types of joints; [7] the effect of roll-on joints in eliminating build up in tension due to temperature drops in cast-iron pipe, and of doing away with more expensive lead or cement joints; [8] the greater crushing strengths of cast-iron pipe where heavy wheel loads are expected, and the use of recommended trench load designs when soil conditions require the use of asbestos-cement pipe; [9] the use of copper wire over asbestos-cement pipe to facilitate locating pipe in the future; [10] evidence indicating that decomposed granite is conducive to heavy corrosion, although its resistivity readings are high.

Conclusions

In the light of published data to date and the result of this investigation, it is concluded that:

1. There is a place for both asbestos-cement and cast-iron pipe in a water distribution system. The items listed in the preceding section cover some of the considerations that should not be overlooked in making the selection.

2. An area resistivity map can be a great aid in making the correct selection of pipe to be used.

3. Asphalt-base mastic coating forms a most excellent protective covering for a steel line.

4. Upon careful examination of asbestos-cement pipe which had been in service for approximately 15 years at each of three test sites with what was considered to be the most corrosive soils in the area, no evidence of outer surface softening of the pipe was noted. All specimens withstood by a substantial margin the hydrostatic test pressures required at the factory for the particular class of pipe.

5. The softening of the interior of the San Diego 4-in. Class C asbestos-cement pipe raises the question of whether water curing or some other causes, such as type of cement used or mandril pressure during forming, are responsible for this condition. Water-cured pipe in other systems should be examined in order to shed further light on this question.

6. There is a great need for additional information on the subject discussed in this paper. All individuals and organizations having such information are urged to make it available to the water works industry. With the limited data available to date, entirely opposed conclusions appear to have been drawn by representatives of the cast-iron pipe and the asbestos-cement pipe industries.

7. Any doubt regarding the durability of asbestos-cement pipe created by the Romanoff-Denison report (*1*) has been eliminated in the mind of the authors, insofar as soils in the test area are concerned.

8. In installations of cast-iron pipe in soils of medium resistivity, a sand backfill should be used around the pipe. It is suggested that the sand be fine in order to make it more difficult for the native soil particles to penetrate.

9. For cast-iron pipe installations, great care must be exercised to insure that the sand is free of clay balls and is not contaminated during installation of the pipe. This is not easily accomplished and requires very rigid inspection.

Acknowledgments

The authors wish to express appreciation to the Cast-Iron Pipe Research Assn. and to the Johns-Manville Corp. for their suggestions and other assistance in this investigation. The tests on the asphalt mastic–coated steel pipe and the cast-iron pipe were performed in the presence of representatives of the Research Assn., using its hydrostatic testing equipment. Representatives of two of the leading cast-iron pipe manufacturers also witnessed the tests. Representatives of the Johns-Manville Corp. witnessed the field tests on the asbestos-cement pipe and made available all testing facilities in its factory at Watson, Calif. The San Diego Water Dept. provided two of the test sites and its supervisory staff assisted greatly in this study. The Los Angeles Dept. of Water and Power provided one of the tests sites and its supervisory and technical staff assisted very greatly in planning the test program, in conducting the tests, and in evaluating the data obtained. Particular credit must be given M. K. Socha, assistant chief engineer of water works at Los Angeles, whose suggestions have proven invaluable.

References

1. ROMANOFF, MELVIN & DENISON, IRVING A. Final Report—Effect of Exposure to Soils on the Properties of Asbestos-Cement Pipe. *Corrosion* (May 1954).
2. UHLIG, HERBERT H. *Corrosion Handbook.* John Wiley & Sons, Inc., New York (1948).

Part 3—Safe Working Practices

After several years of study, AWWA Committee A2.E—Safety Practices has prepared a manual of safety practices for water utilities. This is the fifth installment (the previous four appeared in the July 1955 issue, p. 637; August, p. 791; September, p. 923; October, p. 989). The manual will be made available as a separate volume for easy reference. Publication date and price information will be given in a future issue of the Journal.

Section 23—Chemical Handling (Continued)

Sodium Chlorite

The following safety procedures should be adopted to minimize or eliminate hazards:

Handling and Storage

1. Sodium chlorite products are buff-colored salts, shipped as a flaked solid in lithographed steel drums (100 lb net weight) equipped with flowed-in rubber gaskets (Interstate Commerce Commission Specification *37-D*). According to ICC regulations, these drums are single-trip containers and cannot be reused for chlorite products. All shipments carry a yellow label ("Oxidizing Agent") and must go forward by freight, either rail or truck, or by railway express—*never* by parcel post or air express.

2. Sodium chlorite products are powerful oxidizing agents that have equivalent available chlorine contents of 110–130 per cent. The dry material is extremely stable under ordinary atmospheric conditions. The product itself is not sensitive to mechanical shock and is nonexplosive, but the dry or moistened solid forms a dangerously explosive and combustible mixture with organic matter, such as oil, grease, alcohol, aldehydes, wood, paper, and clothing. The dry or moistened solid reacts vigorously with sulfur and sulfur compounds—such as sulfides, sulfites, and hydrosulfites—and even with rubber that has been vulcanized with sulfur.

3. Both the dry product and solutions react with acids to liberate chlorine dioxide gas, greenish yellow to reddish yellow, which, in air mixtures at concentrations of more than 30–35 mm Hg partial pressure, may explode as a result of sparking or exposure to heat or sunlight. The odor of chlorine dioxide is evident at approximately 10–14 ppm and is sufficiently irritating at 45 ppm to produce a headache. The gas is more insidious than chlorine, as the former does not have the choking effect that the latter has and, therefore, does not immediately cause violent coughing. Thus, persons will allow themselves to be exposed to ClO_2 for a much longer time than to chlorine, with the result that final symptoms may be much more severe. The physiological effect of ClO_2 is similar to that of chlorine in that the mucous membranes are irritated, resulting in edema. Symptoms are usually similar to those of a common cold but in severe cases may resemble a quick pneumonic crisis.

4. Universal (Type *N*) gas masks or acid-gas and organic-vapor masks (Type *AB*) approved by the US Bu-

reau of Mines should be used to provide protection against chlorine dioxide gas.

5. In handling either the dry material or solutions, all possible care should be taken to avoid spillage. If sodium chlorite solution touches a wooden floor, a deposit of small, finely divided crystals in intimate contact with the wood fibers will occur on drying. Friction caused, for example, by running a hand truck over the floor or by the scuffing of a workman's shoe may cause ignition.

6. Clothing on which chlorite has been accidentally spilled should be carefully washed with water and not allowed to dry while the chemical is still present in the fibers. Locker fires have occurred because of failure to observe this precaution.

7. If a fire breaks out in a drum of chlorite, the danger should be controlled by adding a few shovelfuls of soda ash or sand. Water should not be sprayed into a burning drum because of the hazard of explosion. When possible, the drum should be removed to a point where no damage can be done and the fire should be allowed to burn itself out. An 8-in. steel rod to which has been welded a steel ring approximately 2 in. larger in diameter than the OD of the chlorine drum is a useful tool for handling drums under such conditions.

8. A small quantity of burning chlorite, such as a few pounds on a floor, are easily handled by a stream of water. If this is not available, a shovelful of soda ash will help confine the fire.

9. Chlorite products should be stored only in their original containers in a cool, dry area, out of contact with oxidizable materials, reducing compounds, sulfur and sulfur compounds, and acids. Covers should always be kept in place to avoid contamination. Only absolutely clean, all-metal equipment, used for just such service, should be employed in handling the chemical. Spillage of either the salt or solution should be avoided. In case of accidental spillage, the flakes should be swept into an all-metal container and flushed down a drain with large amounts of water. The area on which the dry product or solution has been spilled should be washed free of all chlorite.

First Aid

Although chlorite has no noticeable effect on the skin, exposed areas should be washed as soon as possible. If chlorite is accidentally splashed into the eyes of an operator, they should be washed immediately with large amounts of water.

Section 24—Bacteriological and Chemical Laboratories

General Laboratory Precautions

1. Put all chipped, cracked, or broken glassware into containers marked "For Broken Glass Only" for final disposal. Do not put this material in wastebaskets. In sinks used for washing glassware, place removable wire mesh false bottoms to prevent cut fingers by allowing the smaller pieces of broken glass to fall through to the sink bottom; they can be removed later when the sink is drained.

2. Clean up immediately all broken glassware and spilled water and chemicals. Dispose of discarded chemicals in such a way that they cannot cause injury to anyone.

3. Perform all work that involves the use of volatile acids, bases, or solvents under a hood. Wear a face

shield when charging apparatus or inspecting such operations.

4. Do all ether and chloroform extractions under a hood, with the door down and the fan on; avoid inhalation of fumes.

5. Perform all flame work in a hood; keep the burners in a line; never reach over a flame.

6. Do not perform work involving flames and flammable solvents in the hood at the same time; keep all open flames away from flammable chemicals.

7. Never work in a poorly ventilated area.

8. Learn the locations of fire hoses, fire extinguishers, fire blankets, and stretchers; if the work involves a fire hazard, keep the proper extinguisher within easy reach.

9. Become familiar with the type of fire extinguisher to use for each kind of fire.

10. When diluting acid with water, always add the acid slowly to the water, while stirring. Adding water to concentrated acid causes spattering, evokes heat, and may give rise to acid burns of skin and clothing.

11. Never handle any chemical with the hands; always use the proper spatula, spoon, or tongs.

12. Do not discharge such liquids as oil, grease, mercury, gasoline, ether, and other solvents into laboratory drains. The drainage system may pocket vapors and present an explosion hazard. Nitric acid and mercury will quickly destroy lead pipe traps and fittings. A polyethylene sink trap can be used to catch accidental spillage of mercury.

13. Dilute acids and alkalies and flush them down the sink drains with large amounts of water.

14. Wear protective safety glasses or plastic face shields when there is danger of flying particles or spattering of liquids.

15. Use protective gloves and tongs when handling hot solutions or residues.

16. Wear laboratory protective garments at all times.

17. Use suction bulbs on pipets when handling dangerous or volatile chemical or serological solutions; never create suction with the lungs and mouth.

18. Locate a well stocked first-aid kit in an easily accessible part of the laboratory; follow the posted first-aid instructions and learn how to use the various items in the kit.

19. Operate an instrument only after a complete study of the instructions furnished with it.

20. Never try to repair or tinker with apparatus or instruments that are not thoroughly understood.

21. Wear a protective hat in areas where the head room is low.

22. Do not neglect any accident, no matter how insignificant; apply first aid and then notify the person in charge.

23. Never use laboratory apparatus for the preparation and serving of food or for drinking.

24. Provide small, portable stepladders; stepping or climbing on stools to make adjustments or readings limits a workman's ability to move rapidly and, therefore, is a dangerous practice.

25. For efficiency and safety, keep the laboratory rooms neat and clean at all times; return all equipment not being used to the cupboards or stockrooms; always keep benches and the floor clean and free of unused equipment.

26. As a part of regular laboratory routine set aside a cleanup period at the end of each shift or workday; re-

move trash as soon as it accumulates and at least once a day.

27. When installing laboratory apparatus, avoid blocking access to the main control valves or switches. Reaching through a complicated apparatus to shut off the gas or water valve or heat switch may upset the equipment and cause personal injury. Plan the setup for safety.

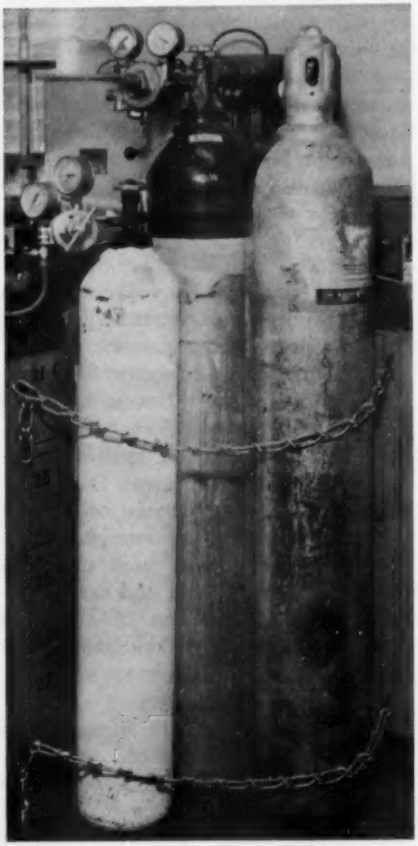


Fig. 34. Safety Chains Around Cylinders

Safety chains should be placed around chemical cylinders to prevent them from falling over.

28. Protect all workers in the bacteriological laboratories with antityphoid vaccine; keep immunization effective with the necessary booster shots.

29. Do not take chances with bacteria; use proper sanitary technique at all times, particularly when working with pathogenic or unknown bacteria; do not leave containers of harmful bacteria where they can be available to unauthorized persons; keep such bacteria in locked cabinets when not in use.

30. When measuring test portions of raw water of unknown origin from industrial wastes or sources that may be polluted with domestic sewage, use pipets with a small plug of cotton at the mouth end for personal protection.

31. Thoroughly swab working surfaces with an effective bactericidal agent before and after planting samples; use generous amounts of the agent for cleaning up spills.

32. Keep all bench and desk drawers closed in order to avoid tripping and collisions.

33. Instruct workers to place safety chains around chemical cylinders to keep them from falling over (Fig. 34).

34. Watch out for tripping hazards, particularly when carrying glassware; be ready for the high step when entering and leaving walk-in refrigerators and incubators.

General Apparatus Precautions

1. Weak, damaged, or imperfect apparatus should never be used. As soon as a piece of equipment is found to be defective, it should be removed from service and either repaired or destroyed. A regular maintenance

and inspection schedule should be established for all but expendable laboratory equipment.

2. Connections of rubber to glass should be made carefully. Long lengths of glass tubing should be supported while they are being inserted into rubber. The ends should be fire polished and a lubricant—water, glycerine, or a water-soluble lubricating jelly—should be used. Grease or oil should never be employed for lubricating glass-to-rubber joints.

3. Gloves should be worn or a towel used when making a glass-to-rubber connection. The tubing should be held as close as possible to the end being inserted, to prevent bending or breaking. A glass tube should not be forced into a rubber stopper hole that is too small, as the glass may splinter and cause severe injury.

4. Flasks and beakers larger than 1 liter should not be heated directly; this equipment should be heated in a bath, by a steam jacket, or by an electric mantle.

5. A wired or shatterproof glass shield should be used with all glass equipment where there is danger of collapse or explosion; even though a shield is used, the operator and other persons in the vicinity should wear safety glasses.

6. Connections of rubber tubing to glass should be clamped; the tubing should be reinforced at kink points or protected with wire spirals.

7. All glassware should be emptied and rinsed before being set aside for cleaning. If the container has held particularly toxic or corrosive materials, it should be cleaned by the chemist before washing. The use of strong oxidizing agents for removing organic residues is dangerous. See Table 13 for a partial list of hazardous chemicals and paragraph 8 under the heading Chemical Reagents in this section for mention of some strong oxidizing agents.

Pressure Equipment

1. Because all pressure equipment is potentially dangerous, it should be tested regularly and never put to any use other than that prescribed without approval of the laboratory supervisor.

2. When desiccators are used for vacuum work, they should be enclosed in wire or metal baskets.

3. Solid desiccants should be used in desiccators. If concentrated sulfuric acid must be employed, the splash hazard can be reduced by putting glass wool or diatomaceous earth into the desiccator well.

Heating Equipment

1. Materials that may liberate flammable vapors when heated should be dried in steam-heated ovens.

2. Air baths are adequate for many purposes for which oil or metal baths are commonly used. When solid oil, salt, or metal baths are used for high-temperature heating, great care must be taken to prevent water or organic materials from falling into the bath. A fire may result or bath materials may be scattered about and cause serious burns. Regardless of the bath materials, the operator should wear asbestos gloves, a laboratory coat or apron, and safety glasses.

3. Whenever heat is to be applied to apparatus for a long time, steam or electricity should be used instead of gas.

Electrical Equipment

1. Cords to all electrical apparatus should have acid- and waterproof insulation; they should be frequently inspected for deterioration, loose contacts, or shock hazards.

2. Special power-driven equipment, such as ball mills and vacuum pumps, may accumulate static electricity; static eliminators should be installed on all such equipment.

3. Belts, drive shafts, gear trains, and other exposed moving parts of laboratory machinery should be provided with safety guards.

4. All electrical equipment should be installed in accordance with the practice of current codes. Electric circuits should be of sufficient size and capacity to permit maximum delivery from all outlets at the same time. Overloaded circuits have caused serious injury to workers and equipment.

5. Electrical outlets and conduits should carry a separate grounding wire or connection, so that all equipment can be grounded. Vapor- or explosion-proof switches and fixtures must be provided in all hoods and in all rooms where corrosive fumes are present or flammable gases and solvents are used.

6. All laboratory work, particularly where a hazard is involved, requires adequate lighting—at least 50 foot-candles at every work surface.

7. Asbestos gloves with gauntlets should be worn when handling hot materials from ovens and sterilizers; the latter should be handled carefully to avoid strain or damage to the temperature-sensitive units and to prevent the contents from spilling out when the door is reopened.

8. Electric ovens should be shut off and left to cool for 45 min before the contents are removed. A cart should be used for transporting hot materials in wire baskets or heavier containers.

9. Electrical equipment should not be allowed to remain unattended at night while turned on unless it is equipped with a reliable temperature control and is located in a completely fireproof section of the room. Workers should check to make sure the switches on the electric sterilizers and drying ovens are turned off at the end of the day.

10. Workers should avoid the possibility of serious burns by labeling hot materials "HOT" immediately after their removal from ovens or sterilizers.

Storage

1. All apparatus should be stored when it is not in use.

2. Heavy equipment should be kept on lower shelves or pallets.

3. Glass tubing should be stored horizontally with its ends protected. Other glass equipment should not project beyond the supporting shelves. Shelves that hold small apparatus or equipment likely to roll should be fitted with retaining lips.

4. Damaged equipment that is kept in the stockroom until it can be repaired or destroyed should be plainly labeled as defective and kept away from items in good condition.

Specific Apparatus Precautions

The following safety procedures should be adopted to minimize or eliminate hazards:

Autoclaves

1. Do not permit autoclaves to be used by workers unless they have been thoroughly instructed in the safe operation of such equipment.

2. Load the autoclave in accordance with the space requirements of the material to be sterilized and in such a manner that hot material will not fall out or spill when the door is reopened.

3. As leakage of steam from around worn or cracked door gaskets and valve stems can cause burns and scalds, check to see that door gaskets are

TABLE 13

Partial List of Incompatible Chemicals *

Chemical	Prevent Contact With:
alkaline metals (such as powdered aluminum or magnesium, sodium, and potassium)	carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, and halogens
acetic acid	chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, and permanganates
acetylene	chlorine, bromine, fluorine, copper, silver, and mercury
ammonia, anhydrous	mercury (such as in manometers), chlorine, calcium hypochlorite, iodine, bromine, and hydrofluoric acid anhydrous
ammonium nitrate	acids, metal powders, flammable liquids, chlorinates, nitrites, sulfur, and finely divided organic or combustible materials
aniline	nitric acid and hydrogen peroxide
bromine	ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, and finely divided metals
carbon, activated	calcium hypochlorite and all oxidizing agents
chlorates	ammonium salts, acids, metal powders, sulfur, and finely divided organic or combustible materials
chlorine	ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, and finely divided metals
chlorine dioxide	ammonia, methane, phosphine, and hydrogen sulfide
chromic acid	acetic acid, naphthalene, camphor, glycerine, turpentine, alcohol, and flammable liquids in general
copper	acetylene and hydrogen peroxide
cumene hydroperoxide	organic or inorganic acids
flammable liquids	ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, and halogens
fluorine	everything except special containers

* Adapted from the "Dangerous Chemicals Code," Bureau of Fire Prevention, Los Angeles, Calif. (1951).

TABLE 13 (*contd.*)

Partial List of Incompatible Chemicals *

Chemical	Prevent Contact With:
hydrocarbons (such as butane, propane, benzene, gasoline, and turpentine)	fluorine, chlorine, bromine, chromic acid, and sodium peroxide
hydrocyanic acid	nitric acid and alkalies
hydrofluoric acid, anhydrous	ammonia, aqueous or anhydrous
hydrogen sulfide	fuming nitric acid and oxidizing gases
hydrogen peroxide	copper, chromium, iron, most other metals and their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, and combustible materials
iodine	acetylene, hydrogen, and ammonia, aqueous or anhydrous
mercury	acetylene, fulminic acid, and ammonia
nitric acid, concentrated	acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, and flammable liquids and gases
oxalic acid	silver and mercury
perchloric acid	acetic anhydride, bismuth and its alloys, alcohol, paper, and wood
potassium	carbon tetrachloride, carbon dioxide, and water
potassium chlorate	sulfuric and other acids (*see also* chlorates)
potassium perchlorate	sulfuric and other acids (*see also* chlorates)
potassium permanganate	glycerine, ethylene glycol, benzaldehyde, and sulfuric acid
silver	acetylene, oxalic acid, tartaric acid, fulminic acid, and ammonium compounds
sodium	carbon tetrachloride, carbon dioxide, and water
sodium peroxide	ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, methyl acetate, and furfural
sulfuric acid	potassium chlorate, potassium perchlorate, and potassium permanganate (or similar compounds of such other light metals as sodium and lithium)

* Adapted from the "Dangerous Chemicals Code," Bureau of Fire Prevention, Los Angeles, Calif. (1951).

smooth and without cracks and replace leaking stem valves immediately.

4. Close the autoclave door snugly and turn the wheel to tighten the lugs firmly, in order to prevent steam pressure from blowing out the door gasket.

5. Be certain that the waste valve is closed tightly and that the exhaust valve is wide open before the steam supply is turned on.

6. To avoid burns, wear asbestos gauntlets when closing the exhaust valve.

7. When the sterilization period is over, always close the steam supply valve first and then let pressure drop to zero in accordance with the established procedure and the requirement of the material.

8. When opening the autoclave, slowly turn the wheel to loosen the door lugs completely; a "tight" wheel may indicate the presence of steam pressure; wait 1–2 min before trying the wheel again; open the door slightly and stay out of danger while the steam vapors dissipate; then open the door completely and let the apparatus cool for a few minutes.

9. Use asbestos gloves with gauntlets for unloading the contents of the autoclave and for further handling of the hot materials. Wear a protective apron and keep a good grip on the hot materials so that droplets or spilled material will not cause injury.

Pipet Cleaner

1. Always wear a rubber apron, rubber gloves, and safety goggles or a face shield when operating a pipet washer unit; the soaking jar contains corrosive acid.

2. When transferring pipets from the acid jar to the rinsing unit, allow the pipet to drain over the acid jar completely or hold an agatewear vessel under the pipet container while moving it; immediately rinse the dipper with large amounts of water.

3. Avoid dripping or spilling the acid; clean up immediately all acid that has come in contact with protective clothing or the counter top.

4. If acid from the unit comes in contact with skin or clothing, wash the area at once with large amounts of water and notify the person in charge.

Water Stills

Workers operating electrically heated water stills for producing distilled water must observe these safety rules for the protection of the individual and equipment:

1. Before any other operation, always turn on the water entering the unit and regulate it for proper flow control. Be sure that the still is filled with water before the heating unit is turned on. If the boiling unit is not filled with water to the proper level, the heating coils will burn out unless the still is equipped with a low-water control. Check after a few minutes to see that everything is functioning properly.

2. Never leave a still unattended for a long time, as an interruption in the water flow may ruin the equipment.

3. If the still is operating improperly or is not distilling water, always turn off the electric circuit before investigating; the heating unit may be burned out or shorted; an open circuit could be fatal to a person who comes in contact with the still if it is not properly grounded.

4. Units equipped with an automatic low-water shutoff are reasonably safe to operate; they are the only kind that can be left in operation overnight while unattended, as long as they are situated in a fireproof section of the laboratory.

Flame Spectrophotometer

1. Some flame spectrophotometers use a 6-v wet-cell automobile type battery, which contains sulfuric acid. When inspecting the battery, be careful to avoid getting acid on hands, clothing, or equipment. Never check the specific gravity while the charger is in service as acid may spattter from the cells during the charging period.

2. Be absolutely certain that the charger leads are connected to the battery correctly before the charger is attached to the 110-v circuit; a wrong connection will burn out fuses and may ruin the charger.

3. The flame spectrophotometer uses an oxygen, air, and gas mixture to produce an open flame; follow the detailed instructions in their proper sequence; improper mixtures of oxygen and other gases may cause an explosion and backfiring.

4. Turn on the cooling water for the chimney before the flame is lighted.

5. To avoid explosions, always start the operation of the flame with a gas light and make sure it is on until the correct oxygen and air mixture is burning at the proper rate.

6. Because oxygen gas is dangerous in confined spaces, observe the following rules in its handling and use:

a. Never store oxygen cylinders near other compressed gases or combustible material.

b. Check connections and equipment frequently by the soap bubble test to locate leaks.

c. Never use oil or grease to lubricate oxygen valves or connections as these substances may cause an explosion; be sure that the leads from the oxygen cylinder valves to the instrument in use are safe and will stand a pressure of at least 50 psi; avoid the use of rubber tubing for conducting oxygen, because these two materials may ignite.

d. Never allow the pressure-reducing valve to deliver oxygen at a pressure of more than 35 psi.

e. When stopping the operation of the equipment, first close the main valve on the oxygen cylinder, and allow oxygen to bleed through the flame burner until the gage indicates that there is no pressure; then shut off the fuel supply and close the pressure-reducing valve. Check occasionally during this procedure to see if there is any reading on either pressure gage on the oxygen tank. If pressure is noted, the cylinder valve is not closed tightly. A leaking cylinder valve can create sufficient pressure to blow out the safety disc in the pressure-reducing valve and allow escaping gas to accumulate in the room, possibly producing a serious fire hazard.

Hot Plates

1. Never use a bare hand to determine if a hot plate is turned on; always assume it is hot until it is determined otherwise.

2. Always turn off hot plates when they are not in use.

3. Use hot plates in a hood, where fumes or released gases or vapors can be drawn off to avoid contamination of the air in the room.

4. Never place cool flasks or containers directly on a hot plate unless it is certain that no danger is involved; check the list of procedures and operations and make sure that the laboratory test can be safely done on a hot plate.

5. Always use asbestos gloves or tongs for handling materials from the hot plate; do not take chances that may result in a serious burn.

6. Never try to remove spattering acid or caustic containers from the hot

plate unless a face shield, a rubber apron, and asbestos or rubber gloves are worn.

7. Do not permit smoking or the presence of open flames near the hot plate when combustible gases or vapors are being produced on it.

Muffle Furnace

1. Muffle furnaces normally operate at high temperatures; when putting in or removing hot materials, wear asbestos gloves and use long-handled furnace tongs as protection from burns.

2. Maintain a good grip on the hot materials when they are transferred from the furnace to the desiccator or other container.

3. Set the furnace for the proper temperature before putting in any materials; turn off the furnace when it is not in use.

4. Never burn volatile substances that may cause an explosion in the furnace; the inside of the furnace is a confined area.

5. Never burn materials that will produce acid or alkali vapors in the furnace; such materials will corrode the heating elements and eventually burn them out.

Instruments for Testing Radioactivity

1. Instruments for testing radioactivity are similar to television sets in that both operate at high voltages. Shut off the instrument and disconnect all electrical power connections before repairs or adjustments are attempted inside the cabinet.

2. Do not permit laboratory personnel to operate these instruments unless thorough instruction has been given in the proper sequence of operation. Do not allow the controls to be operated by workers unless they have been properly instructed. (The delicate instruments can be easily thrown out of adjustment by the turn of the wrong knob.)

3. Use proper precautions in handling radioactive materials; post warning and "Hands Off" signs for the protection of other personnel; strictly follow laboratory instructions for storage or disposal of radioactive substances.

Centrifuge

1. As the centrifuge is high-speed equipment, always be sure that it is in proper balance before it is placed in service.

2. Always set the centrifuge for the proper speed for the material and container being used.

3. Before placing glass containers in the centrifuge, check them for chips or cracks; a cracked vial or bottle may fly apart at high speeds, throw the instrument off balance, set up a serious hazard, and ruin the centrifuge.

4. Always keep the cover closed when the centrifuge is in motion; bring the rotor to a complete stop before lifting the cover.

Chemical Reagents

1. The supply of all reagents kept in the laboratory workroom should be as small as possible; all reagents not actually being used should be returned to the storeroom.

2. All containers should be clearly labeled to identify completely the materials they contain; original labels showing the batch analysis should be preserved on the container by covering them with plastic, paraffin, or transparent tape.

3. Unless identification is easy and positive, unlabeled chemicals should be disposed of by someone who understands the risks involved and will act accordingly.

4. New chemicals, which appear regularly on the market, frequently have

properties that are neither generally nor completely known. Before releasing such substances for general use, all of the available information on them should be obtained from the supplier and passed on to the laboratory personnel. Careful small-scale tests may be made on all unknown reagents to determine their hazard potential.

5. All chemicals should be smelled cautiously. The bottle should never be held directly under the nose but, rather, held away and the vapors should be wafted to the nose with a gentle motion of the hand. When inhaling, only the top of the lungs should be used, as they should always remain filled with enough clean air so that the fumes can be completely expelled from the nose and upper respiratory tract.

6. Pipets to be used with strong or otherwise dangerous solutions should never be filled by mouth. The tube should be filled by immersion or with a suction bulb. When a pipet is to be filled or a siphon started with suction applied from an aspirator, a pump, or vacuum line, a scrubber trap should always be placed in the suction line.

7. Lighting fixtures should be explosion-proof and, where possible, reagents should be stored out of direct natural light. Shelves should be low and not crowded. Reagents likely to react together should be stored apart from each other.

8. Strong oxidizing agents, such as nitrates, nitric acid, permanganates, peroxides, perchlorates, chlorates, and perchloric acid, must be stored and handled in such a way that mixture with easily oxidized materials, such as sulfur, sulfides, and glycerine, will be avoided. If pressure-sensitive materials, like perchlorates, must be kept in the laboratory workrooms, only small quantities should be stored in wide-mouthed bottles fitted with loose, soft-rubber stoppers. Large amounts of perchloric acid should be kept in isolated storage outside the laboratory buildings. Ammonia should be stored away from the halogens.

9. Containers of flammable or caustic materials should be stored in crocks or lead trays, so that if breakage occurs, the dangerous substances will be confined.

10. Metallic sodium and potassium should be kept in stone or glass containers under kerosene; phosphorus pentoxide containers should be kept tightly closed; anhydrous aluminum chloride should be supplied in small quantities, and, once opened, the material should not be stored longer than 3 weeks.

11. Finely divided magnesium or zirconium, dimethylarsine, triethyl bismuth, bromates, nitrogen halides, Grignard reagents, and organic zinc compounds should be cautiously handled and stored.

12. When powdered, the alkaline metals (magnesium, sodium, potassium, and aluminum) will react with carbon dioxide; therefore, carbon dioxide extinguishers cannot be used on burning alkaline metals.

13. The quantity of ordinary flammable chemicals present in a laboratory workroom should be kept as small as possible. The supply should never be greater than that required for one shift or 1 day. Where there is a rapid turnover in flammable solvents, workroom containers should not hold over 5 gal. Usually, 1-gal containers will be large enough. These should be of the safety type approved by the Underwriters' Laboratories, the Factory Mutual companies, or other such testing organizations.

14. Operations involving volatile flammables should be carried on within troughs or large trays with raised edges

under exhaust hoods. If a fire starts, it may be controlled much more easily if the burning material can be confined. The use of electric heating mantles for the refluxing and distillation of volatile flammable solvents like ethyl ether and petroleum ether will minimize some of the dangers involved.

15. Smoking should be discouraged in laboratory workrooms and absolutely forbidden in storage rooms or wherever a fire or explosion is possible. Areas in which smoking is permitted should be clearly marked and kept clean and comfortable.

16. Extreme care should be exercised in storing ethers, to prevent the formation of explosive peroxides. Activated charcoal or aluminum oxide can be used in ether storage cabinets to absorb the peroxide. Specific inhibitors can be used with some ethers to prevent the formation of explosive peroxides. If the volume is reduced below 10 per cent when ether is distilled, a peroxide explosion may occur. The serious explosion hazard involved in the distillation or refluxing of ethers cannot be overemphasized.

Toxics

1. All laboratory reagents should be considered toxic, even though only some are labeled as such.

2. In laboratories where toxic material is handled, personal hygiene cannot be overemphasized. A shower and complete change of clothing should be compulsory at the end of each workday. Personnel working with toxic substances such as lead or nitrobenzol should have periodic medical examinations.

3. The toxic effect of many chemicals is underestimated:

a. Hydrogen sulfide in concentrations greater than 20 ppm is toxic and produces respiratory paralysis. The intensity of the characteristic rotten-egg odor of this gas does not function as a warning, because the sensitivity of the nose to the odor may be lost after a very short exposure. Mixtures of air with this gas (in the range of 4 to 46 per cent by volume) are explosive.

b. Under normal atmospheric conditions, an exposed surface of 4 sq in. of mercury can produce a toxic concentration (0.2 mg per cubic meter) in a small workroom after a few minutes. The probable safe concentration of mercury for an 8-hr exposure is 0.1 mg per cubic meter. Therefore, mercury should be used only in well ventilated rooms, and, if the exposed surface is large, as when several manometers are employed, the work area must be constantly monitored.

c. The effects of exposure to the oxides of nitrogen are sometimes not manifest for 48–72 hr. A single cough at the time of exposure may be the only warning of an exposure that may result in serious lung edema and death.

4. Mercury should be handled over trays with raised edges so that spillage can be completely recovered. A high-speed aspirator fitted with a trap and a fine nozzle is useful to recover mercury caught in small cracks, but there is not much that can be done to remove it from porous material. Contaminated surfaces, bench tops, and wooden or concrete floors can be treated with ammonium or calcium polysulfide by the Randall process.

Corrosives

1. Cup goggles or face shields, gloves, and aprons should be worn whenever acids or alkalies are transported or transferred. Wherever these materials are used, large quantities of bicarbonate of soda should be available. Spilled acids and alkalies should be neutralized and cleaned up immediately.

2. Use of polyethylene reagent bottles will greatly reduce the chance of spillage and splashing from accidental breakage; because these containers are so light, however, they overturn very easily when they are only partially full.

Compressed Gases

1. Compressed gases should be stored vertically, with the shipping caps on. Oxygen cylinders should be separated from cylinders of flammable gases. Gas storage areas should be isolated from laboratory workrooms and other storage places.

2. If cylinders are stored out of doors, it may be necessary to keep them under a water spray during summer so that internal pressure will remain within safe limits.

3. While in use, a cylinder should be clamped or chained in an upright position; flammable-gas containers should always be grounded.

4. Reduction valves, gages, and other fittings designed for oxygen cylinders should not be used on other cylinders. The threading on cylinder fittings usually prevents their interchange, but it is quite possible to exchange fittings on homemade installations and small cylinders with clamp-on adapters. Every effort should be made to prevent this from being done. Fittings for oxygen cylinders should be kept free from oil and grease.

5. Extremely corrosive gases like chlorine and hydrogen bromide should be bought and stored in small quantities only, unless they are to be used in a relatively short time. Valves on corrosive-gas cylinders deteriorate rapidly. Everyone working with these gases should know what to do when a valve fails.

Maintenance and Personnel

1. A safety inspection and maintenance schedule for all laboratory equipment should be established as part of regular laboratory operations. Workers should consult their supervisor whenever doubt arises about procedure or equipment safety.

2. Instructions on the work done in the laboratory should be given to all laboratory personnel so that they will be able to appreciate the hazards of their own work and that of others.

3. The use and the hazards of new or unusual equipment should be thoroughly explained.

4. It is particularly important to indoctrinate new workers properly. Careful instruction should be given in the use of personal protective equipment and fire-fighting apparatus. A thorough first-aid course is essential, even though the laboratory policy may require that a physician treat all injuries. All laboratory personnel should be able to apply artificial respiration.

Section 25—Office Worker Safety

Office workers should avoid injury by exercising reasonable care and judgment in the performance of their daily job. Injuries of any degree should be promptly reported to the supervisor. The following safety procedures should be adopted to minimize or eliminate hazards:

1. Desks and cabinet drawers, which are tripping, collision, and stumbling hazards, should be kept closed and out of the way; workers should be careful not to pinch fingers when closing drawers.

2. Tilting a chair backward is hazardous; persons have been injured by chairs that slipped or broke under the added strain of tilting.

3. The use of ordinary pins to fasten papers together has been the cause of

many scratched and pricked fingers. To avoid scratches and possible infections, clips should be used, but if it is necessary to use pins, workers should handle them carefully.

4. Workers should always be careful when handling paper because it may cause painful cuts; envelopes should not be licked, as their edges may cut the tongue—a sponge or water wheel should be used.

5. Pencils, pens, and other pointed instruments should be carefully handled to avoid puncture wounds. Pencils should be pointed downward when in the pocket. They should not be carried between fingers with the points in the palm of hand or extended toward others.

6. Defective chairs and desks are hazards that may result in injury and should be reported to the supervisor.

7. If left on the floor or across passageways, cords from telephones or electrically operated office machines may cause persons to trip and fall; such wires should be placed along the wall or in flat metal housings.

8. Because workers may collide with doors, they should be kept closed or opened all the way.

9. Good housekeeping is a keynote of safety; workers should keep their desks clean and orderly.

10. Sharp-pointed vertical paper files on desks are dangerous; such points should be bent horizontal.

11. Horseplay and skylarking (including the shooting of paper wads, paper clips, and rubber bands) should not be permitted.

12. A standard four-drawer correspondence file can be hazardous, as it may upset and cause injury if an overloaded top drawer is pulled out.

13. Because serious hand injuries may be inflicted by electric fans, they should be kept off desks and should be high enough above the floor to be out of reach. Specially designed fans for floor use are safe.

14. Workers should not walk hurriedly from rooms into corridors; when walking, employees should keep to the right, especially at corners.

15. Combustible material should not be kept closer than 6 in. from steam pipes or radiators.

16. Stoppered bottles should not be heated by placement on radiators or steam pipes, as the heat may cause the containers to explode.

17. Employees should never hurry when using stairways. High heels are particularly dangerous. Handrails should be used wherever possible.

18. Because they may fall and cause injury, articles should never be placed on window sills, filing cabinets, lockers, and other elevated objects.

19. Hands should be carefully kept clear of danger when windows, doors, and gates are opened or closed.

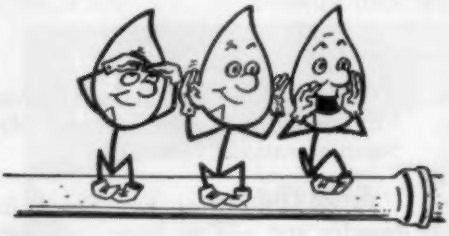
20. As knives and razor blades are hazardous when uncovered, they should not be left with exposed cutting edges in desk drawers.

21. Qualified helpers should move heavy objects; hernias, sprains, strains, and splinters may result from lifting or shifting equipment and supplies.

22. Oily clothes, photographic film, glass, and razor blades should never be deposited in wastebaskets, because such objects may cause injury to the janitors; hazardous materials should be placed in a receptacle used solely for that purpose.

23. Employees should be careful in using broken porcelain faucet handles or walking on slippery, waxy, or wet floors and loose materials.

24. "No Smoking" signs should be observed.



Percolation and Runoff

Glug is the word from the Northeast these days—glug upon glug, as extratropical cyclone has followed hurricane tail to engulf the area in two major floods in less than two months. And if the ill winds have blown the reservoirs finally full, not many have had the heart to celebrate that fact in the face of the general destruction.

Actually, of course, water works themselves were anything but unscathed by the two blows, high water having destroyed facilities or knocked out service completely in many of the communities affected. The Torrington, Conn., water system was one of those virtually swamped in the backwash of Diane, and it required heroic efforts not only by the water company staff, but by a host of friends and neighbors as well, to get the water back inside the system again. Two engineers from the American Water Works Service Co. of Philadelphia, two from Metcalf & Eddy Engrs. of Boston, one from the New England Div. of the US Army Corps of Engineers, and one from the Bridgeport (Conn.) Hydraulic Co. volunteered aid in directing the reparations. Meanwhile, the Greenwich Water Co. and the Bridgeport utility, as well as local industry, sent along labor crews to help with the heavy work. And then, not long after the first aid had been rendered and service was heading back toward normal, Diane's nameless follower let loose with another dose of the same elemental stuff. Just how well the Torrington system held up under the second blow has not yet been revealed, but the number of "boil water" warnings and bridges out and power failures in the area suggests the probability of another floody mess.

Relatively pampered in the past, the Northeast has been getting more than its share of Nature's excesses during the past few years, and little by slow has been getting itself geared for disaster. Here, too, it seems, experience has been the best teacher, though a fantastically expensive one and a little too specialized, for each new type of storm has offered something new in the way of trouble. As far as prevention is concerned, Northeasterners, too, gave up waiting some time ago, but there is some indication that they have finally accepted their new status as hurricane-, flood-, and cyclone-prone, and will now begin a really serious effort to organize their defenses. For the moment, however, reparation rather than preparation is the order of the day and the the word is still "glug!"

Victims of the October floods and, apparently, of the novelty of an "extratropical cyclone" were Edward A. Phoenix, known to AWWA members as Johns-Manville's market survey

(*Continued on page 36 P&R*)

(Continued from page 35 P&R)

man, and his wife, both drowned in the Saugatuck River at Redding, Conn., on the night of Oct. 15. Failing to appreciate the power of the flood waters built up in two full days of rain, the Phoenixes did not hesitate to drive home from a visit with some neighbors when a phone call from their 13-year-old son informed them that their power had failed. Although it is reported that they did hesitate en route before crossing a bridge that was already awash, they apparently decided to take a chance and were carried away when the bridge collapsed—Ed to immediate death and Mrs. Phoenix to be drowned after 3½ hours of clinging to a tree and seeing one rescue attempt after another fail. Their accident, given full coverage in the metropolitan newspapers, may well save other lives in suggesting caution in dealing with flood waters—but at what a price!

Frank C. Amsbary Jr. has just moved to Long Island to assume the post of vice-president and general manager of the Long Island Water Corp., Lynbrook, N.Y. AWWA President Amsbary was formerly vice-president of the Northern Illinois Water Corp., Champaign, Ill. Both companies are owned by the Charles S. Mott interests.

H. K. Gidley and W. S. Staub have become partners in the firm of W. D. Kelley, consulting engineer of Charleston, W.Va. The firm will do business under the name of Kelley, Gidley & Staub. Mr. Gidley was formerly director of the Div. of San. Eng., West Virginia Dept. of Health, and Mr. Staub was vice-president of the West Virginia Water Service Co., Charleston. Both men are active in AWWA affairs, Mr. Gidley as West Virginia Section secretary and Mr. Staub as national director.

B-I-F Industries has closed its foundry and will no longer manufacture pipe fittings. The company will thus be able to concentrate more fully on equipment for metering, control, and chemical feeding marketed by its divisions, Builders-Providence, Omega Machine Co., and Proportioneers. The company's pipe fitting patterns have been sold to Warren Foundry & Pipe Corp., which maintains a stock of fittings at Everett, Mass. Warren is said to be able to furnish all types and sizes of B-I-F fittings, as well as those in its own line.

Samuel B. Morris has retired as general manager and chief engineer of the Los Angeles Dept. of Water & Power but will remain as an adviser to the department on major water projects, as well as on atomic power (he was a member of the United States delegation to the Geneva atoms-for-peace conference and was named to the Joint Congressional Atomic Energy Committee's national civilian advisory panel).

William S. Peterson, assistant general manager and chief engineer since 1953, succeeds Mr. Morris and is himself succeeded by Burton S. Grant. The latter's position as chief engineer of water works, which he has held since 1950, will now be filled by Samuel B. Nelson, Mr. Grant's assistant. Max K. Socha, engineer of water distribution, becomes assistant chief engineer of water works. Mr. Peterson, an electrical engineering graduate of the University of California, started with the department in 1922 and advanced

(Continued on page 38 P&R)


HAYS
AMONG THE HAYS
WATER WORKS PRODUCTS
that you need to
save time and
expense . . .
DRILLING MACHINE
TAPPING MACHINE
Write for literature, or ask "The Man from Hays"
(FOR OVER 80 YEARS)
CORPORATION STOPS • CURB STOPS
SERVICE BOXES • FITTINGS
BRANCH CONNECTIONS • GOOSENECKS
Join the A. W. W. A. HAYS is one of the eleven Charter Members of the Manufacturers Section of the American Water Works Association.
HAYS
WATER WORKS PRODUCTS
HAYS MANUFACTURING CO.
ERIE, PA.

(Continued from page 36 P&R)

to the top position in the power system before becoming assistant general manager.

Arthur M. Buswell has resigned as chief of the Illinois Water Survey to accept a position as research professor in the Dept. of Chemistry, University of Florida, Gainesville, where he will participate in an expanded program of water research. Under Dr. Buswell's leadership, the Illinois Water Survey, which he headed from 1920 on, developed into one of the largest units of its kind in the United States, with a staff of more than 50 scientists and technicians.

A competitive examination for appointment of sanitary engineer officers to the Regular Corps of the US Public Health Service will be held at various places throughout the country Jan. 10–12, 1956. Minimum requirements are United States citizenship and graduation from a recognized engineering college or university. For appointment to higher ranks, additional professional training and experience are necessary. Application forms may be obtained by writing: Chief, Div. of Personnel, Public Health Service, Dept. of Health, Education & Welfare, Washington 25, D.C. Completed forms must be received in the Div. of Personnel no later than Dec. 9, 1955.

Neptune Meter Co. announces the appointment of John J. Moran and Bill L. Sidebotham as sales representatives. Mr. Moran's territory will be Long Island and Westchester County, N.Y.; Mr. Sidebotham's, central and northern California.

(Continued on page 40 P&R)

(*Continued from page 38 P&R*)

P&R's foreign agents have been extra active of late in giving us the water word from all over the world, and if some of their communiques have been rather less than significant, at least they suggest that water is a worry and a wonder wherever:

• ALASKA: Water rates at Nome check out at approximately a nickel per gallon or, in Noman terms, 8 bucketsful for $1. Actually buckets are not only the metering, but the distribution, devices as well, and the charges are basically for applied heat. That makes it fire water in only the weakest sense, however, for even under the label, "Igloo Juice," it can't compete with the beverages that incorporate antifreeze.

• BELGIAN CONGO: At a cost of $40,000,000, the Fonds du Bien Etre Indigene (FBI to Belgians), a royal agency created "to assist in the material and moral development of that part of the native society of the Belgian Congo and the neighboring Ruanda-Urundi which has continued to live on the basis of tribal organization," built a 140-mile concrete pipeline to the mountains and a complete purification system to supply native villages with a source of safe water. In operation only 8 hr per day, the system can supply native families with 30–50 gpd, compared to the 4 gpd that was all the women of the villages were able to tote home on their heads over the 10-mile return trip usually required to bring water to the villages in the rich but impermeable volcanic ash areas from distant rivers and lakes. Not just the boon to sanitation, but the tremendous release of womanpower to provide for the comfort of their men, has made this project popular even with the natives.

• BRAZIL: At Sao Paulo, water distribution this past summer was even more primitive than that of Nome, water being peddled in the streets by the quart at unmentioned and, undoubtedly, unmentionable prices. Cause of the reversion was the worst drought in more than 30 years, which put the thirst particularly to the 5,000,000 residents of Rio de Janeiro and Sao Paulo.

• EGYPT: Following a Rockefeller Foundation survey which revealed a 100 per cent dysentery rate and a high incidence of typhoid and other waterborne diseases in many of its villages, the Egyptian government financed a project by which 600,000 villagers in the Faiyoum area, near Cairo, were provided with purified well water in place of their old and rare stuff from the muddy Nile. And now, with financial aid from the United States, the national government expects to finish the job of providing a safe supply to all 20,000,000 inhabitants of the Nile Valley—a measure likely to have so profound an effect upon the health of the valley that the Sphinx, himself, may feel good enough to smile.

• INDIA: To speed progress and interest in water and sewage works, a Public Health Engineering Group has been set up under the auspices of the Institution of Engineers (India) with AWWA member B. V. Bhoota as secretary. Interested in promoting research and information to advance the cause of public health engineering in India, the group has already purchased copies of *The Story of Water Supply* and *Your Water Supply,* AWWA's public relations booklets.

• IRAN: Just last month the Caspian Region of the Ministry of Health's Public Health Cooperative Organization opened the valves on its first water

(*Continued on page 42 P&R*)

(*Continued from page 40 P&R*)

supply and distribution system, which will supply Bandershah, a city of 15,000, through a 7-mile transmission line. Having constructed the entire system between June and October, with all labor—including digging and backfilling—done by hand, Major Hagar, Point Fourman on the job, is outbeaming the Iranian sun, and Mohammad Assar, acting chief of the organization's sanitary engineering division, has joined AWWA.

● Iraq: To provide its population with pure water from rivers "not usually noted for their purity," the government of Iraq has purchased a floating purification unit which takes water from the river on which it floats and pumps it, purified, to nearby villages through its own pipelines. First unit of what is expected to be a fleet, exhibited at the Baghdad Fair last year, was constructed of aluminum alloy and had a capacity of 40 gpm. Designed to be towed to the village or area most in need of its services, this vessel sounds like an even more practical peace ship than our proposed atom boat.

● Israel: In mid-July the opening of a 65-mile, 66-in. pipeline carrying the water of the Yarkon River to the Negev Desert heralded completion of the first stage of a project designed to irrigate 100,000 acres and support more than 25,000 families. With its roots in the ages, this development was said to represent the fulfillment of "one of the persistent aspirations of mankind." Even more persistent perhaps was the aspiration fulfilled in early August with the opening of the 12-in. connection between the Yarkon-Negev line and Nazareth, where the water is being piped into the homes of the city, homes that have had to get

(*Continued on page 44 P&R*)

(Continued from page 42 P&R)

along with a bucket distribution system supplied by such sources as the famous "Well of the Virgin."

• NORTHERN RHODESIA: Summing up his rather depressing report of the 1954 struggle to improve water supplies, T. W. Longridge, director of water development and irrigation, describes the familiar difficulty of obtaining qualified men for the job. The conclusion to his report points out:

> Keen interest in all kinds of water development work is shown by both Europeans and Africans, but financial stringency has greatly limited the amount of actual construction done. The department has not been able to work to its full capacity on construction during the year under review due to the tightness of money. However, no time has been lost or wasted. Valuable knowledge of our territorial rivers and streams has been gained. Staff have been employed on investigation and survey of schemes and areas, ready for the time when money becomes easier.

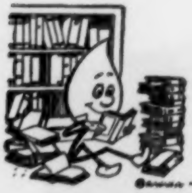
Water workers do seem to have a universal language.

• PERU: Floods and landslides from heavy rains last spring cut off the water supply for Lima's 850,000 inhabitants, and flood waters from the swollen Rimac River contaminated the city's reservoirs. Lima, Peru, that is, not Connecticut.

Next month, East Lynne!

Joseph H. Boigegrain, formerly S. Morgan Smith Co. Pacific Territory district manager for valve sales, Temple City, Calif., has been named assistant to the sales manager of the company's Valve Div. at York, Pa. Harry A. Doell, of San Francisco, takes over as district manager for valve sales, as well as turbine sales.

(Continued on page 88 P&R)



The Reading Meter

Irrigation and Hydraulic Design: *Vol. I—General Principles of Hydraulic Design. Serge Leliavsky. Macmillan Co., New York (1955) 492 pp.; $25*

This first volume of a three-volume text on hydraulic design presents a thoroughly satisfactory combination of pure theory and practice. Drawing from 40 years' experience as teacher and designer (predominantly Egyptian government service), the author has produced a hybrid by combining the principles of fluid mechanics with the familiar "handbook." Because of the comprehensive analytical treatment accompanying the general solution of specific problems, the text would be equally suitable for advanced student or designing engineer. Profusely illustrated and containing many data in charts and tables, the three chapters of Volume I fulfill the author's announced objective of producing a text for the "designer's daily work."

Chapter 1 contains a detailed analysis of the two major problems—uplift pressure and undermining caused by percolation—of the designer of dams built on pervious material. The comparable designs resulting from the early empirical methods and from the modern technique based on the potential flow theory are interesting. The circle is shown to be useful in the graphical flow net construction—both as a check on the validity of networks derived by other methods and as a tool in drafting the network. Apparently, the electrical analog has not been developed as extensively in Egyptian use as in American.

Chapter 2 presents a wealth of experience on the "tail erosion" downstream from existing structures, the remedial measures to prevent further scour, analyses of scour from model studies, the proper control of the tail roller, and cavitation. Chapter 3 contains an excellent discussion of formulas for uniform flow and a comprehensive treatment of free water surface profiles for steady, nonuniform flow in open channels.

Volume II and III, in preparation, will be titled "Irrigation Works" and "Hydraulic Structures for Irrigation and Other Purposes," respectively. When complete, the book will be "a large order" in more ways than one.

Elements of Hydraulic Engineering. *Ray K. Linsley Jr. & Joseph B. Franzini. McGraw-Hill Book Co., New York (1955) 582 pp.; $9*

This textbook for senior civil engineering students is broadly divided into three parts. The first deals with hydrologic and legal considerations more-or-less common to all hydraulic projects. The second part discusses hydraulic structures such as reservoirs, dams, and pipelines, and their appurtenances. Special problems of the various branches of hydraulic engineering are covered in Part III. Although the student will not learn all he needs to know about water supply engineering or any other specialty, the book will give him a unified picture of the entire hydraulics field.

Handbook of Engineering Materials. *Douglas F. Minor & John B. Seastone, ed. John Wiley & Sons, New York (1955) 1,390 pp.; $17.50*

More than 50 specialists participated in the preparation of this handbook, which is designed to aid the engineer in the proper selection of materials, particularly those outside the field of his immediate

(Continued on page 48 P&R)

The Reading Meter

(Continued from page 46 P&R)

specialization. Thus, although the book does not specifically cover the water works applications of materials, it provides a large fund of data that should prove useful in this field. The handbook is divided into four main sections, separately paged, covering general information, metals, nonmetals, and construction materials. Tables and graphs, as well as text, are utilized to present data on fundamental properties, fabricating qualities, availability, and costs. The arrangement and quantitative character of the information facilitate comparisons of competitive materials.

Abstract of Laws and Recommendations Concerning Water Well Construction and Sealing in the United States. *Report No. 9, Water Quality Investigations, California Div. of Water Resources, Sacramento, Calif.; order from Printing Div., Documents Section, N. 7th St. & Richards Blvd., Sacramento, Calif. (1955) 391 pp.; paperbound; $3.50*

This report abstracts existing legislation and recommendations adopted by 25 states and 20 California counties and cities, as well as the recommendations of the Federal Housing Administration, the US Public Health Service, and AWWA. Among the subjects covered are permits, location, logs, construction, development, pump installation, disinfection, and sealing.

Cryptogamic Botany: *Vol. I—Algae and Fungi. Gilbert M. Smith, McGraw-Hill Book Co., New York (2nd ed., 1955) 546 pp.; $8.50*

In his preface, the author states that "this book is designed for students who have had an introductory course in botany and who wish to make a more intensive study of plants below the level of seed plants. It is written from the standpoint that a thorough knowledge of a representative series in each of the major groups is better than scraps of information about a large number of members of each group. . . . In certain cases, as with the diatoms and the blue-green algae, it has been thought more advantageous to present the group as a whole instead of discussing selected representatives."

Illustrations are in black and white. Bibliographical references are given at the end of each chapter. Until an up-to-date work on this subject written specifically with the water supply field in mind becomes available, this book should prove a useful addition to the water works library.

The Technology of Cement and Concrete: *Vol. 1—Concrete Materials. Robert F. Blanks & Henry L. Kennedy. John Wiley & Sons, New York (1955) 422 pp.; $11*

Admitting that there are many gaps in present-day knowledge of concrete, this book sets out, in as nontechnical language as possible, the known facts about the materials used in making concrete. Particular attention is given to portland cement and aggregates. An attempt has been made to cover those phases of the subject about which information is not readily available. The second volume, now in preparation, will deal with the most effective combinations of the various materials and with the properties and uses of the resulting concretes.

Plastics Engineering Handbook: *Society of the Plastics Industry. Reinhold Publishing Corp., New York (2nd ed., 1954) 813 pp.; $15*

So much new information has been made available since the publication of the original *SPI Handbook* in 1947 that it has been necessary to expand the new edition to nearly twice the size of its predecessor. As difficult as it must be for plastics industry engineers and technicians to keep abreast of new and many-sided developments, it is obvious how much greater this difficulty is for personnel in

(Continued on page 50 P&R)

The Reading Meter

(Continued from page 48 P&R)

the water works field, where the application of plastics is still in its infancy. This handbook will not—and is not designed to—help the water works engineer select specific commercially manufactured products for his particular purposes. It does, however, offer a great deal of information on the properties and processing of plastic materials, design standards and tolerances, assembly and finishing, and testing.

Water and Sewage Works Training Manuals: *Unit I—Basic Water Works Operation; Unit II—Advanced General Water Works Operation; Unit IV—Surface Water Production; Unit V—Water Distribution. Texas Engineering Extension Service, Texas A&M College, Box 236 F.E., College Station, Tex. Looseleaf, paperbound; price per unit, including instructor's lesson plans, $1*

These manuals contain course outlines, suggested lesson plans, and review tests, as well as study material for the trainee, in the form of resumes of the topics discussed in class. Developed from experience gained in years of teaching water works personnel at the largest school of this type in the country, these manuals are well suited for in-service instruction. (Unit III—Ground Water Production was still in preparation when this review was written.)

Manual for Sewage Plant Operators. *Clayton H. Billings, ed. Texas Water & Sewage Works Assn., Austin, Tex. (2nd ed., 1955) 511 pp.; $6.50*

Changes from the first edition (1947) include a new chapter on oxidation ponds and the deletion of the chapter on sand filtration. A number of other chapters have been rewritten. Various aspects of sewerage are covered, including design and maintenance of facilities, organization and financing of systems, treatment methods and equipment, stream pollution, laboratory control, and commercial utilization of treatment products. There is a chapter on Texas standards for design, operation, and reporting. Definitions of terms are listed in an appendix.

Proceedings of the Fourth Annual Water Symposium. *Bul. No. 51, Engineering Experiment Station, Louisiana State University, Baton Rouge, La. (1955) 118 pp.; paperbound; $1.50*

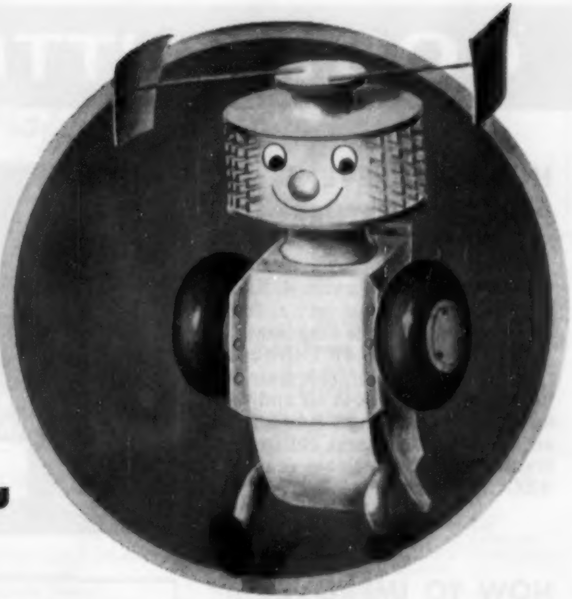
Papers presented at this symposium, Mar. 22–23, 1955, and included in these *Proceedings,* deal with the following topics: US Army Corps of Engineers water resources developments and their effects on industry; public water supply quality standards; industrial use of ground water in Louisiana; stream pollution; salt water disposal; and others.

Forestry Handbook. *Reginald D. Forbes, ed. Ronald Press Co., New York (1955) 1,212 pp.; $15*

Prepared under the supervision of the Society of American Foresters, this handbook is intended to provide in a single volume the essential facts of forest and wildlife management, including such related subjects as aerial photography, protection against fires and diseases, watershed management, and surveying. The many tables and illustrations help make it an invaluable reference work for those concerned with this field.

Appraisal and Valuation Manual, 1955–56. *American Society of Appraisers, 100 W. 42nd St., New York 17, N.Y. (1955) 394 pp.; $15*

This manual consists of a number of articles on various phases of real estate appraisal and valuation, written by men connected with some of the leading appraising firms in the country. Among the subjects covered are depreciation studies, rate base regulation, property records, original-cost valuation, and expert testimony. A table of 1955 local building costs and a list of the society's members are also included.



Professional Services

Professional Services

Professional Services

Condensation

Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

BACTERIOLOGY

A Comparison of Standard Lactose Broth With Lauryl Sulfate Broth and With the Eijkman Method for Demonstrating Fecal-Coliform Bacteria. H. T. PEDERSON JR. & C. E. SKINNER. Appl. Microbiol., 3:55 (Jan. '55). Many studies have been made to compare lauryl sulfate broth and other presumptive media for coliform bacteria in water. Present authors, from Dept. of Bacteriology and Public Health, State College of Washington, consider there is still doubt as to effectiveness of lauryl sulfate broth in detecting all fecal-coliform bacteria in sample. Same might well apply to standard modification of Eijkman test. Authors, therefore, compared present official (APHA) Eijkman test with lauryl sulfate broth and standard lactose broth in their respective effectiveness as enrichment media for fecal-coliform organisms. 120 fresh samples of human feces were suitably dild. and inoculated into respective media, and incubated at 37°C in case of lactose and lauryl sulfate broths. Eijkman medium was divided into 2 replicate sets, incubated at 45.5°C, 1 in hot-air incubator, and other in water bath. Readings were made at 24–26 hr and again, if necessary, at 48 hr, and positive tubes of highest diln. were confirmed by official methods. MPN of coliform bacteria per 1 cc was detd. from statistical tables. Results are analyzed statistically and discussed in detail. Lauryl sulfate broth is at least as productive as lactose broth for coliform organisms from feces; it is believed that the former broth is not more productive. Modified Eijkman broth in hot-air incubator at 45.5°C was neither more nor less productive than standard lactose broth at 37°C, but it was clearly superior to Eijkman broth incubated in water bath. No one method proved superior to others in eliminating false positive-coliform tests under conditions of these expts. Not all *Aer. aerogenes* strains from feces were inhibited by Eijkman broth at 45.5°C.—*BH*

A Comparison of the Molecular Filtration Technique with Agar Plate Counting for Enumeration of *Escherichia coli* in Various Aqueous Concentrations of Zinc and Copper Sulfates. E. L. SHIPE JR. & A. FIELDS. Appl. Microbiol., 2:382 (Nov. '54). Certain industrial wastes may contain copper and zinc in amts. of no more than 1 ppm and yet may affect detection of coliform organisms by membrane filtration technique. Failure is due to adsorption of ions to membrane during filtration and so the bact. cells, exposed to concd. amts. of toxic substances, fail to develop into colonies. Expt. is described in which *Esch. coli* cells were suspended in various concns. of copper sulfate and zinc sulfate; after 4 hr at 25°C, cell concn. in solns. was estimated by agar plate counts and membrane filtration. Results indicated that ratio of recovery by agar plate counts to that obtained by membrane filtration was affected by concn. of copper or zinc salt present; greater is concn, larger is ratio. Copper sulfate affected results more than zinc sulfate.—*BH*

A Study of 200 Egyptian Strains of Fecal *Esch. coli*, With Special Reference to a Brilliant-Green Medium for the Bacteriological Examination of Water Supplies. A. LACKANY. J. Egypt. Med. Assn. (Egypt), 37:1100 ('54). After discussion of optimum temps. and favorable media for cultivation of *Esch. coli*, author, from Alexandria, describes expts. with 200 strains of coliform bacteria isolated from feces in Egypt. Main object of work was to repeat expts. of Mackenzie and others with brilliant-green lactose bile at 44°C and to compare this method with incubation at 45.5°C, as favored by workers in the United States. Because most of the ingredients used in the medium employed by Mackenzie and others are not easily available outside dollar areas, author prepared medium with ingredients of British make, except that Bacto peptone was employed. Brilliant green was tested in

(*Continued on page 64*)

22 MINUTES
for Complete Hydrant Inspection
WITH RENSSELAER

The illustrations show how easy it is to remove and inspect the entire mechanism of the Rensselaer-Corey Fire Hydrant which has been the standard in many cities for more than half a century.

The parts can be removed, inspected, and replaced in twenty-two minutes. No digging for repairs or for standpipe breakage. This hydrant opens with the pressure, by means of the powerful knuckle joint. Easy to operate and cannot stick. It is quick opening with free flow long radius curves. Hydrant will not flood.

Ask for Catalog No. G and see why the Rensselaer-Corey Hydrant is preferred by superintendents, fire chiefs and maintenance men. 106D

Rensselaer VALVE CO. **TROY, N. Y.**

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

SALES REPRESENTATIVES IN PRINCIPAL CITIES

Division of The Ludlow Valve Manufacturing Co., Inc.

(Continued from page 60)

various dilutions in order to standardize it to concn. of Bacto brilliant green of original medium. 0.005% was found most suitable—a concentration 3.7 times higher than that of American dye. Final medium used contained 20 g sodium taurocholate, 10 g Bacto peptone, 10 g lactose, 0.05 g brilliant green, and 1,000 ml distilled water. Coliform strains were isolated and classified by recognized methods. For gas production, each strain was tested both at 44°C and 4.5°C incubation in this medium and in modified Eijkman medium used by Hajna and Perry. Results, which are tabulated, showed that in every case incubation at 44°C was superior to that at 45.5°C. With 182 strains of *Esch. coli*, Type 1, brilliant-green lactose bile medium was more suitable for gas production (95.7%) than modified Eijkman medium (85.2%). Prolonging incubation period to 48 hr raised percentage of positives by 11–14% when incubation was at 45.5°C, but made little difference at 44°C. Only 10 strains of *Esch. coli*, Type 2 and 3 intermediate strains were available, but in this small series there was little to choose between media. 5 strains of Irregular Type 6 were isolated; one of these failed to produce gas in modified Eijkman medium. This type had not been recorded from Egypt before. —*BH*

A Comparative Study of Some Methods for Detection of Coliform Bacteria in Water. S. D. Henriksen. Acta Pathol. Microbiol. Scand. (Denmark), **35**:2:143 ('54). Aim of study to compare some of most common methods for detection of coliform bacteria in order to find out which of these best suited Norwegian water supplies. The methods were: primary incubation in lactose peptone broth at 37°C; primary incubation in MacConkey broth at 37°C; primary incubation in BGB at 44°C; subculture of primary positive tubes into BGB at 44°C and into peptone water to test indole production at 44°C; plating out and differentiation by Gram staining, IMViC reactions and 44°C test. Gas production by coliform bacteria was delayed in MacConkey broth

(Continued on page 66)

(Continued from page 64)

compared with lactose peptone broth; slightly more positive reactions were obtained with the latter medium. False positives due to Gram-positive bacteria were not frequent and there were only half the number in MacConkey broth compared with lactose peptone water, but advantage did not counterbalance disadvantage caused by inhibitory action of MacConkey broth. Frequency of false positive reactions due to Gram-negative rods failing to produce gas from lactose was very high, and these organisms seem to be very common in Norwegian waters. Origin and hygienic signif. of such bacteria are worth further investigation. 3 methods for detection of *Esch. coli,* Type 1 were compared: plating and colony differentiation (CD), primary 44°C test (44P), and secondary 44°C test (44S). No. of water samples shown to contain specific organism was slightly higher with CD than with 44S, but both methods were superior to 44P. For quant. estimation of *Esch. coli,* CD was again slightly superior to 44S, but CD appeared to give best results with lightly pold. samples and 44S with heavy pold. samples. Combination of 2 methods, particularly in water samples containing relatively small numbers of coliform bacteria (up to 50 per 100 ml), would increase reliability of results.

The Heat Resistance of *Streptococcus faecalis.* H. R. White. J. Gen. Microbiol. (Br.), 8:27 ('53). In studies on resistance to heat of *Str. faecalis,* standardized no. of cells was added to flask of saline soln. in water bath at 60°C, samples taken at intervals, and nos. of bacteria surviving detd. Results expressed either as decimal reduction time (DRT), obtained by plotting logarithms of no. of survivors against time, or as time taken to kill 99.9% of bacteria. Death rate curve was not always linear for mature cultures but often showed initial period of low death rate followed by increase in death rate to max. rate which was usually maintained. At times few organisms exhibited abnormally low death rates. With young cultures less than 12 hr old, death rate

(Continued on page 68)

(Continued from page 66)

was uniform. No signif. differences were observed in DRT of cultures with ages varying from 12 to 48 hr. In cultures less than 12 hr old, there was difference in DRT with age, resistance of very young cultures increasing to max. after about 1 hr and then decreasing rapidly to min. after 2 hr; resistance then showed another less marked increase followed by subsequent decrease. It was observed that there was relation between resistance to heat and phases of growth of these young cultures. The greatest resistance occurring during initial lag period of growth and the min. resistance occurring just before active reproduction began. Temp. of incubation was found to affect resistance of cultures. Except for very young cultures, cultures incubated at 45°C were markedly more resistant to heat than were cultures incubated as 27° or 37°C.—*WPA*

Comparison of the Membrane Filter With the Most Probable Number Method for Coliform Determinations From Several Waters. E. L. Shipe Jr. & G. M. Cameron. Appl. Microbiol., 2:85 ('54). Waters contg. varying nos. of *Esch. coli* cells were used in comparison of methods for detn. of coliforms. Membrane-filter method and MPN method gave similar results on most samples, with some deviation noted when water contained toxic substances. Nos. of cells present did not affect recovery by either method.—*CA*

The Efficiency of Selenite Broth of Different Compositions in the Isolation of *Salmonella*. W. R. North & M. T. Bartram. Appl. Microbiol., 1:130 ('53). Strains of *Salmonella* were cultured in selenite broth contg. different types of peptone or different batches of same type to compare eff. of different compositions as enrichment media. Very variable results were obtained, many media showing low productivity and some giving negative results. In study of possible deficient factors, effect of adding cystine to media was next investigated. It was found that addn. of very small amts. of

(Continued on page 70)

(*Continued from page 68*)

cystine stimulated growth in selenite broth prepared with apparently deficient peptone. Exact amt. for max. stimulation varied with concn. of phosphate used in broth. Commercial selenite preparations contain 1% phosphate but it was found that if concn. of phosphate is reduced to 0.25% and 1.0 μg/ml cystine is added, deficiencies in selenite media otherwise unsatisfactory can be corrected. If satisfactory peptone is used in medium, it is possible that addn. of cystine and reduction of phosphate could result in decreased productivity. Yeast extract was also found to stimulate growth of *Salmonella*.—*WPA*

Comparison of 6-Hour and 24-Hour Incubation Periods at 44°C as a Confirmatory Test for *Bacterium coli*, Type 1. E. Windle Tayor. J. Hyg. (Br.), **53**:50 (Mar. '55). Series of routine water samples were inoculated into MacConkey broth and, after 18 hr of incubation, all presumptive positive tubes (total of 2,478 tubes) were confirmed in single-strength MacConkey broth, BGB, peptone water, and lactose glutamic acid medium. Peptone used in first 3 media was Evans peptone because qual. of peptone used in 44°C test is of greatest importance. Confirmatory media were examd. at 6-hr and 24-hr incubation periods for gas production. In case of peptone water, equal portions of each tube were given indole test at 6-hr and 24-hr periods. By end of 6 hr, 95.5% of all 24-hr confirmed positives had developed gas in BGB, while 94.6% of confirmatory MacConkey broth had acid and gas and 95.6% of indole production occurred in this shorter period. False positive result in double confirmation using either MacConkey broth or BGB with indole test occurred in only 0.24% (6) of 2,478 presumptive tubes confirmed. These false positives were result of either mixt. of organisms or failure to isolate *Esch. coli* from these questionable tubes in further attempt to check disagreement. Results of lactose glutamic acid as confirmatory medium were inferior, particularly with regard to 6-hr incubation period because only 76.4% of all 24-hr confirmed positives had developed acid and gas after this shorter time.—*PHEA*

(*Continued on page 72*)

(*Continued from page 70*)

FOREIGN WATER SUPPLIES—GENERAL

Oxford's £1,700,000 Scheme to Expand Water Supply. H. H. CRAWLEY. Surveyor (Br.), 112:553 ('54). Proposed extensions to water supply system of Oxford are described. Since 1934, avg daily consumption has increased from 2.92 mil gal to 6.38 mil gal. It has been estd. that avg daily demand will be 13.2 mil gal by 1980. At present, max. capac. of water works is 8 mgd, and extensions will be made in 3 stages. By 1955, new water mains will be laid and 4 sand filters will be installed to increase capac. of filtration plant to 10.6 mgd; other improvements will be made at works and 7 new service reservoirs will be constructed. Second stage of expansion will include new water works situated near Thames; and third stage, impounding storage reservoir. —*WPA*

Rapid and Slow Filtration of Water From Lake Constance. Results of Operation of the Water Works of the Town of St. Gallen. E. HOFMANN. Monatsbull. Schweiz. Gas- u. Wasserfach. (Switzerland), 34:77 ('54). Author gives account of experience in and results of operation of filtration plant at St. Gallen Water Works, in which water from Lake Constance is treated first by rapid and then by slow sand filtration. Condition of lake water is first described and results of chem., phys., and biol. examn. are given in tables. Comparison is made between pore size in filters contg. sand of different sizes and size of organisms present in lake water. Exptl. filter contg. 50-mm layer of fine sand, operated as slow filter, was used to collect suspended matter and plankton. Variations in types and numbers of diatoms during 1949–53, predominance at first of *Fragilaria* and later of *Tabellaria*, and effect of alterations in temp. of lake water are discussed. Filter sand used in rapid and slow sand filters is de-

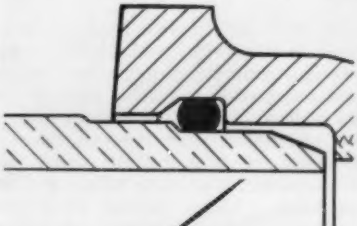
(*Continued on page 74*)

(Continued from page 72)

scribed and account is given of chlorination plant which is used to treat that part of filtrate from rapid sand filters which is beyond capac. of slow sand filters. Second part of article deals with qual. effects of filtration on water. Diatoms like *Tabellaria* and *Fragilaria* were retained to large extent in rapid sand filters, but more spherical-shaped types, such as *Cyclotella*, passed through. Plankton count was reduced by rapid sand filters in 1952 by 88.3% and in 1953 by 92.7%. Effect of maturing of filters and accumulation of film is discussed. Detns., using exptl. sand filter, of vol. of filterable material in raw water and filtrate from rapid sand filters during October and November 1953 showed that 95% of this material was removed by rapid sand filters. Degree of disinfection obtained by both methods of treatment (rapid sand filtration followed by chlorination, and rapid sand filtration followed by slow sand filtration) was satisfactory. Methods of calcg. length of filter runs and improvement in eff. of slow sand filters after addn. of prelim. rapid sand filtration are described and account is given of construction of rapid sand filters and backwashing equipment. Measurements of loss of head were made in 2 sets of rapid sand filters, one of which contained sand of avg size 0.98 mm as compared with 1.2-mm sand of other filters. Coarser sand was considerably more efficient, rates of filtration were greater, and more material was removed from water. After 28½ hr of operation at rate of flow of 5 m/hr, coarser filter showed loss of head of only 8 cm; and finer filter, loss of 85 cm.—*WPA*

The Krefeld Plant for Treating Rhine Water at Krefeld. W. HERRMANN & J. SCHWENZER. Gas- u. Wasserfach. (Germany), **96**:99 ('55). Because ground water supply at Krefeld was inadequate, tests were made to det. best method of treating Rhine water. Method finally selected was flocculation after addn. of $Fe_2(SO_4)_3$ and Cl, with addns. of Na_2SiO_3 and $Ca(OH)_2$, as necessary, to insure flocculation. Flocculation was carried out in conical flocculators, and re-

(Continued on page 76)



RING-TITE JOINT

VALVES & HYDRANTS FOR

RING-TITE ASBESTOS-CEMENT PIPE LINES

MH

For installing M&H Valves and Hydrants in a Ring-Tite asbestos-cement pipe line, specify valves or hydrants with Ring-Tite end connections. The connecting ends of the valve or hydrant are especially designed to enclose a round rubber ring gasket when the end of Class 150 Ring-Tite pipe is inserted, as illustrated in sketch above.

Installation is easy and simple. Unskilled workmen can make up the connection quickly and economically. No special fittings nor extra joint materials are required. The joint is tight against low or high pressure. For full information, wire or write

M & H VALVE AND FITTINGS COMPANY, ANNISTON, ALABAMA

M&H PRODUCTS

FOR WATER WORKS • FILTER PLANTS
INDUSTRY • SEWAGE DISPOSAL AND
FIRE PROTECTION

(*Continued from page 74*)

maining 25% of impurities were removed in open filters. Active C was also added to flocculator to give satisfactory taste. Flow time from flocculator to filter could be delayed for addnl. 11.5 min by using holding tank of sufficient capac.; this facilitated action of active C. Anals. of Rhine water prior to treatment are given. Treated water was free from *Esch. coli* and had satisfactory taste and odor.—*CA*

Thirty-Fifth Report on the Results of the Bacteriological, Chemical, and Biological Examination of the London Waters for the Years 1947–1952. Metropolitan Water Board, London, 116 pp. ('55). 35th report on results of bact., chem., and biol. examn. of London waters supplied by Metropolitan Water Board, deals with 1947–52. High qual. of London's water supply is indicated in introduction to report by record that since 1949, of 47,438 samples examd., 99.84% have been of highest std. of bact. purity. Report deals first with floods in Lee Valley which occurred in March 1947 and caused flooding of Lee Bridge Works with pold. storm waters. There is description of immediate and successful action taken to combat disaster. Account is given of results to date of full-scale expts. undertaken since previous report on clarification of river-derived waters with iron coagulants, aluminium sulfate and activated silica. Expts. devised to compare performance of microstrainers and primary filters have continued since 1948 and are described and discussed at some length. Further work on possible value of strainers using synthetic fabrics has been begun. Sections of report then deal with automatic sampling of water and detection of flow of water underground by means of sodium phosphate. Long bact. section of report contains results of many investigations on such subjects as rapid identification of *Esch. coli* Type I, false presumptive coliform bacteria reactions, and isolation of *Streptococcus faecalis*. Routine bact. examn. of water works employees became policy of board in 1937 and certain aspects of this examn. are here

(*Continued on page 78*)

(*Continued from page 76*)

considered, notably results of about 13 yr of experience with Vi agglutination test. Among 2,502 persons examd. 182 (7.3%) gave positive Vi agglutination test, but from none of these positives were enteric organisms isolated from feces or urine. Also included are results of examn. during past 15 yr of 1,317 men who had suffered recent attack of gastroenteritis. Among these were found 28 men still excreting pathogenic organisms including *Shigella sonnei* (13) and *Salmonella typhi murium* (9). Ever since paratyphoid B fever epidemic at Epping in 1931, sewage and its effluent have been regularly examd. and causative organisms can still be readily isolated, although nos. are fewer than in prewar years. These regular examns. are to continue. There is account of results of examn. of sewage effluents of 10 large towns and of tidal Thames for pathogenic intestinal organisms, and also of investigation into survival of *Salmonella paratyphi B* in septic tank. Chem. section of report contains much information on variety of matters concerned with chlorination, some points in relation to chemistry and use of chlorine dioxide, effect of water on aluminum and amt. of fluorides in board's waters. It is recorded that in 1950, std. procedure adopted for detn. of hardness became disodium salt of ethylene diamine tetraacetic acid (EDTA) method which is here described, as well as its employment for detn. of sulfates. Sensitive tests for small concns. of cyanide in water are also described. Biol. section of report covers large amt. of work done on algal growths in reservoirs and includes reference to chem. anal. of phytoplankton, bionomics of midges, and control of mussels in water pipes. In section on miscellaneous items, there are several interesting short accounts of detective work which was carried out to investigate complaints or observations made to board. One complaint was that underwear turned pink or acquired pink spots on washing; inquiry showed that color was due to action of alk. washing water on phenolphthalein, which had been taken as laxative by wearers of garments.—*BH*

ALLIS-CHALMERS Helps Milwaukee

WATER

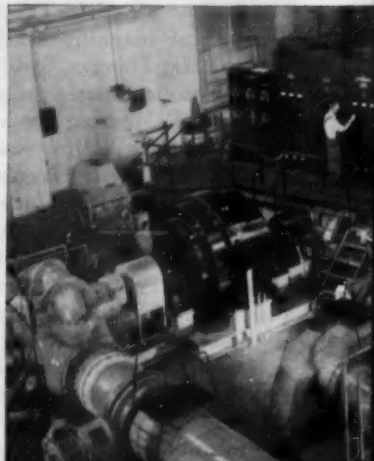
To Keep Pace With Population-Business Growth of Wisconsin's Largest City

IN hustling, bustling Milwaukee, water is used at the rate of 175 gallons per day per person. Within the 100-sq-mile metropolitan area of Milwaukee, there are nearly a million people . . . and two thousand thriving manufacturing firms, including world leaders in the production of heavy industrial machinery, beer, motorcycles, tractors, diesel and gasoline engines . . . all using water in increasing amounts.

Milwaukee's water is obtained from Lake Michigan — through an intake over a mile out and 67 feet deep. Consumption climbed from 22 billion gallons in 1924 to 48 billion in 1954. A record month's high — 6¼ billion gallons — was pumped in August 1955.

Allis-Chalmers equipment now operating in Milwaukee's water system includes large vertical pumping engines — dating back as far as 1890 — at the North Point station, and steam and motor-driven units, electrical equipment and valves at the Riverside station, filtration plant and booster stations. In 1955, as part of a continuing modernization and expansion program, two Allis-Chalmers 30-mgd, motor-driven centrifugal pumps, with controls, substation and butterfly valves, were put into service at the Riverside station.

* * *

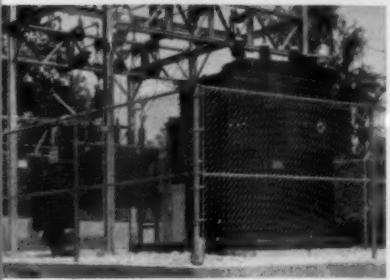


When YOUR CITY plans expansion or modernization, do as other progressive communities are doing — take advantage of Allis-Chalmers many years' experience in furnishing municipal pumping equipment. Call your nearest A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

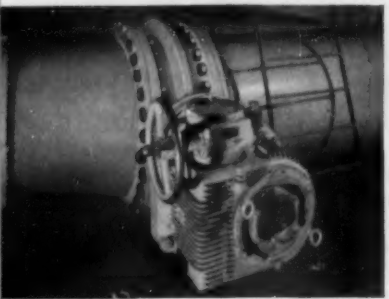
ALLIS-

Milwaukee Journal Photo

Modernize and Expand Water Works

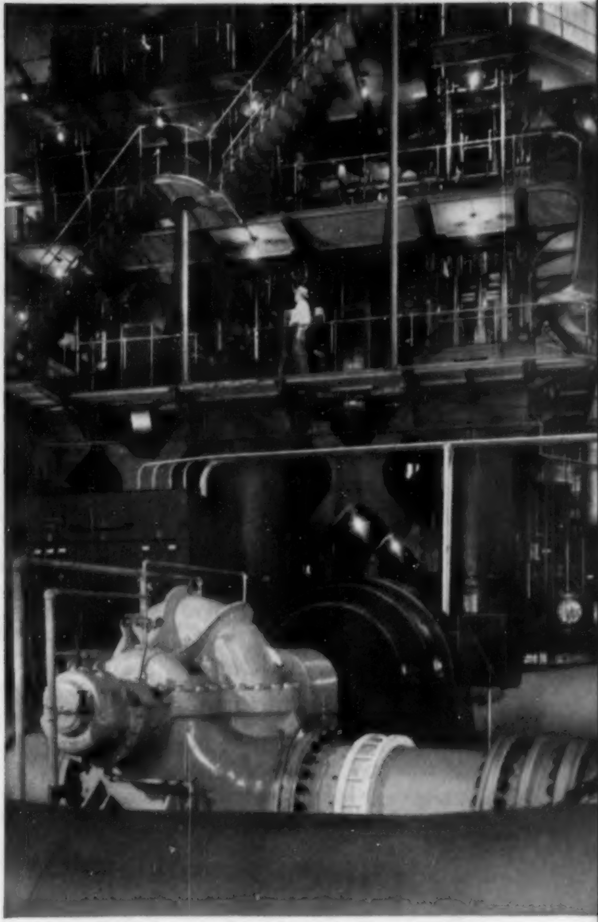


Allis-Chalmers outdoor substation protects and controls electrical power supply for the City of Milwaukee's Riverside pumping station.



Close-up showing one of several of the latest Allis-Chalmers butterfly valves installed at the Riverside station. A-C builds many designs of valves, including units conforming to American Water Works Standards.

Two new Allis-Chalmers 30-mgd pumps and their 2000-hp synchronous motors and controls were fitted into the space formerly occupied by a single 30-year-old, 15-mgd pumping engine.



This view of Riverside station installation dramatizes progress in pump design in the past 30 years. Towering pumping engine in background was record setter in 1924 and is still going strong. But at best it pumps only two-thirds of the water handled by compact new Allis-Chalmers pump in foreground.

-CHALMERS

A-C ALLIS-CHALMERS

Builders of World's Widest Range of Public Works Equipment

A-4857

Section Meetings

Kentucky-Tennessee Section: The 27th annual meeting of the Section was held jointly with the Kentucky-Tennessee Industrial Wastes & Sewage Works Assn. at the Phoenix Hotel, Lexington, Ky., Sep. 12–14, 1955. Joint sessions were held all day Monday and Wednesday morning, with separate sessions on Tuesday. The registration was 217 men and 42 ladies.

At the opening session the groups were welcomed by Mayor Fred Fugazzi of Lexington, and the response was given by Julian R. Fleming, director, Div. of San. Eng., Tennessee Dept. of Public Health. AWWA President Frank C. Amsbary Jr. discussed the effect of air conditioning on present and future water demands. F. W. Kittrell closed the morning session with a discussion of the organization and facilities of the Robert A. Taft Engineering Center at Cincinnati. Mr. Kittrell is in charge of stream sanitation studies at the center, which is under the US Public Health Service.

Opening the afternoon session, Howard D. Schmidt presented a paper on water and sewerage problems in foreign areas, highlighted by colored slides taken in Venezuela. Mr. Schmidt, a former secretary-treasurer of this Section, is now a sanitary engineer for the Creole Petroleum Corp., with headquarters in Maracaibo, Venezuela. Charles E. Coleman, assistant chief engineer, Pump Dept., DeLaval Steam Turbine Co., concluded the session with a paper on maintenance and operation of pumping equipment.

The separate session on Tuesday began with a paper on cathodic protection by J. A. Lehman, Electro Rust-Proofing Corp. A panel discussion on maintenance, operation, and upkeep of water distribution systems was moderated by E. E. Jacobson, Lexington Water Co., with B. E. Payne (Louisville), Earl Graybeal (Kentucky Water Service Co., Somerset), A. E. Clark (Nashville Suburban Utility Dist.), and E. D. Hawkins (Knoxville), participating. The status of fluoridation in Kentucky and Tennessee was discussed by Nick G. Johnson, Kentucky Health Dept., and Jack A. Henshaw, Tennessee Health Dept.

The afternoon session heard two papers and participated in another panel discussion. The influence of chlorine, lime, alum, and other chemicals on the efficiency of activated carbon for taste and odor control was discussed by Al Hyndshaw, Industrial Chem. Sales Div., West Virginia Pulp & Paper Co., Tyrone, Pa. Water supply and storage was the subject of a paper by John L. Thompson, assistant manager, Kentucky Inspection Bureau, Louisville. The Water Works Operators' Forum was led by Ralph C. Pickard, director, Public Health Eng., Kentucky Health Dept. He was assisted by panel members E. L. Johnson, Murfreesboro, Tenn.; James H. Fry, Nashville; and J. W. McCoy, Madisonville, Ky.

The Wednesday morning joint session was devoted to movies, followed by a business meeting. The films shown were: "Flexible Sewer Cleaning Equipment," "Clay Sewer Pipe," and "Every Drop to Drink."

The entertainment provided during the meeting was typical of the hospitality of

(*Continued on page 84 P&R*)

Section Meetings

(Continued from page 82 P&R)

the Blue Grass Country. On Monday the ladies were treated to a luncheon and card party at the historic Duncan Tavern at nearby Paris, Ky. Monday evening a cocktail party in the hotel was enjoyed by all. On Tuesday morning the ladies were taken on a tour of numerous horse farms, including those of Man o' War, Citation, and other thoroughbred greats of the past and present.

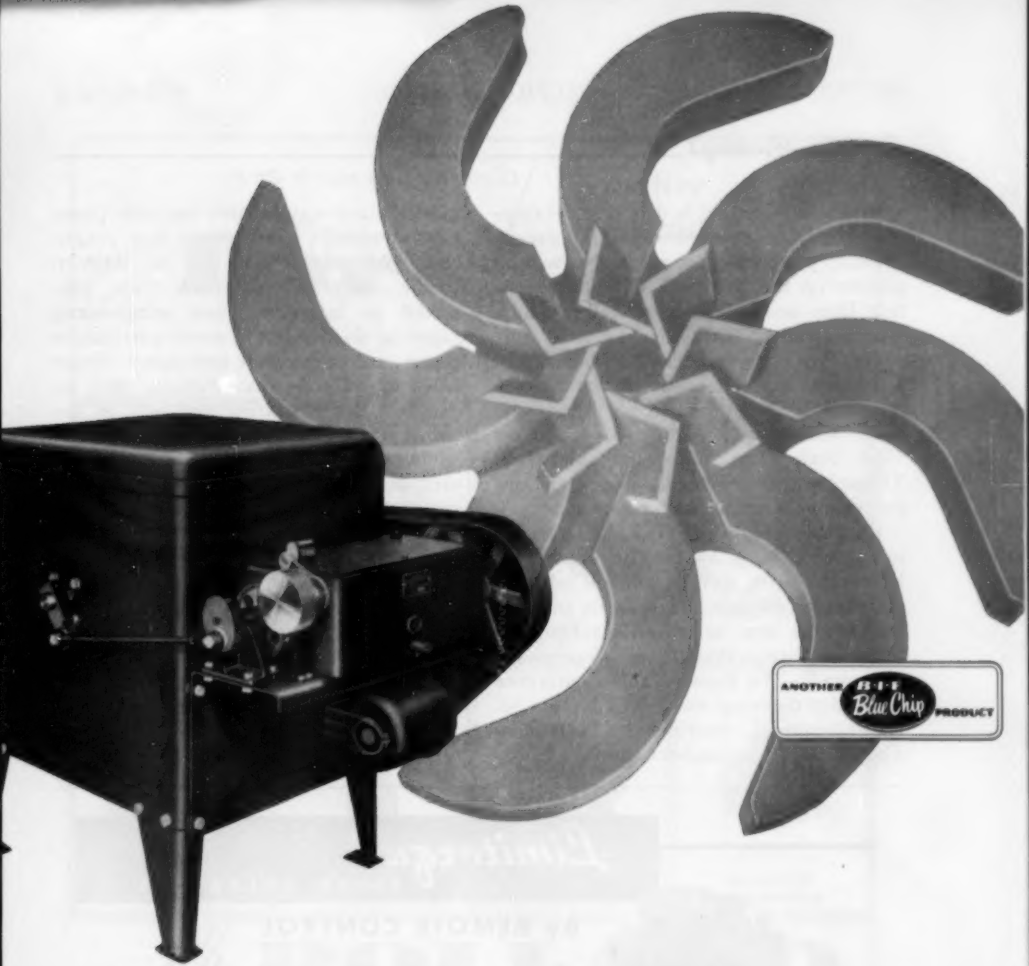
The annual banquet, a feature of which is the absence of speeches, was highlighted by the nomination of Henry M. Gerber, president of the Louisville Water Co., for the Fuller Award, and the presentation of the incoming officers of the Section. The banquet was followed by dancing.

J. Wiley Finney Jr.
Secretary-Treasurer

New York Section: The New York Section held its annual fall meeting at Saranac Inn, Upper Saranac Lake, on Sep. 7–9, 1955. Total registration was 407. George E. Symons, consultant and technical editor from Larchmont, opened the morning program with the "Water Works School." He spoke on the operation of the distribution system, covering service installations, maintenance, hydraulic grade, placing of valves, and flushing. John G. Copley, general manager, Elmira Water Board, presented an interesting paper on water main cleaning. Head loss due to friction, corrosion of metals, methods of cleaning and lining pipe, and slime growths were some of the topics covered. John Schmidt, Meter Dept. supervisor, Board of Water Supply, Utica, concluded the morning session with a talk on meter testing, maintenance, and sizing.

The technical program opened on Thursday afternoon with an excellent talk on pension plans and social security, given by H. Eliot Kaplan, pension consultant, New York City. Mr. Kaplan spoke briefly on the history of the federal pension system and types of pension plans (public and private); the Social Security

(Continued on page 86 P&R)


ANOTHER B-I-F Blue Chip PRODUCT

Section Meetings

(*Continued from page 84 P&R*)

system was discussed in detail. Levi Gaylord, highway superintendent of Jefferson County, presented a paper and a motion picture on the proposed Panther Mountain Dam and its effect on water supply. An interesting discussion followed this paper, with a report by Thomas B. Tyldesley, superintendent of water, Watertown. William Field, consulting engineer, Watertown; George Moore, New York State Dept. of Health; and Jack Thompson, State Water Power and Control Commission, added their comments.

On Friday morning, Wallace T. Miller, research engineer for the Cast Iron Pipe Research Assn., gave a talk on advance planning of water works systems and also presented a new and excellent film, entitled, "Water—Wealth or Worry for America." The Round Table Conference on Friday morning was led by Nelson M. Fuller, general superintendent, Batavia. The following topics were discussed: distribution and maintenance methods (taps, stops, meters); alum versus iron coagulants (Malcolm Pirnie Jr., of Malcolm Pirnie Engrs., New York City, presented an interesting and enlightening paper on this subject); water purification plants; and strain gage techniques (Greer Ellis, of Ellis Assocs., Pelham, gave an excellent demonstration and talk on the use of strain gages; he showed how water hammer can be measured by the use of cathode ray tubes and other electronic devices).

A golf tournament was organized by Bud Moore, Harvey Howe, Les Hart, and Dan Vetromile. Prizes were awarded to Jim Haberer, Les Hart, and Sam McLendon. A special ladies' tournament was held and prizes were awarded to Mrs. Van Deusen, Mrs. Kreutzer, and Mrs. Hart.

KIMBALL BLANCHARD
Secretary-Treasurer


for . . .
Quality
Dependability
Economy
Delivery
Service
DIAPHRAGM PUMPS
MELTING FURNACES
JOINT RUNNERS
CALKING TOOLS
MANHOLE CUSHION
PIPE CUTTERS
SEWERCONNECTIONS
M-SCOPE PIPE FINDER
it's POLLARD
for pipe line equipment
and for Convenience . . .
THE NEW POLLARD CATALOG LISTS HUNDREDS OF MODERN PRODUCTS DESIGNED TO MEET YOUR EVERY REQUIREMENT.
POLLARD
Pollard Catalog 26
PIPE LINE EQUIPMENT
JOSEPH G. POLLARD CO., INC.
Place your next order with POLLARD
If it's from POLLARD . . . It's the Best in Pipe Line Equipment
NEW HYDE PARK • NEW YORK
Branch Offices:
1064 Peoples Gas Building, Chicago, Illinois
333 Candler Building, Atlanta, Georgia

(*Continued from page 44 P&R*)

The Johnstown Flood they undoubtedly labeled him as he kept rising and rising, but he reached his crest 2 ft from the 18th hole on the quarter-final round of the National Amateur Golf Tournament at Richmond, Va., last September. That was Charlie Kunkle Jr., assistant to the general manager of the Johnstown Water Co., Johnstown, Pa., and specialist, no doubt, in water hazards. At any rate, Charlie almost made it this year, defeating Joe Conrad, British amateur champion in the morning, before losing to semifinalist Bill Booe on a 2-ft putt that squirted out of the final hole. Wait till next year—the year of AWWA's 75th Birthday is bound to be the year of Kunkle's Conquest!

Otto E. Brownell has retired as head of the Div. of Municipal Water Supply, Minnesota Board of Health, after 35 years of service with the board. He is now associated with the consulting engineer firm of Toltz, King & Day, St. Paul.

The Illinois Geological Survey celebrated its 50th anniversary in October. Founded in 1905, it now has a full-time technical staff of more than 100 persons to carry on research in the various geo-sciences. Its anniversary program, attended by delegates of national and local societies in geology and related fields, centered around two themes: "the Survey's response to the changing economic pattern of the past 50 years" and "the relation of mineral-resource research in Illinois to the economy of the state."

C. George Dandrow has been named to the newly created post of vice-president for customer relations. Mr. Dandrow continues as vice-president of Johns-Manville Sales Corp.

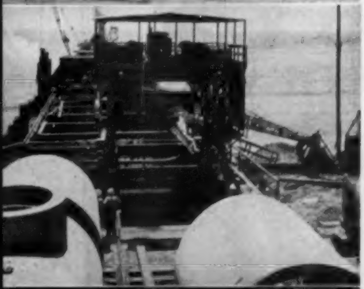
Herman G. Baity has retired as head of the Dept. of San. Eng., School of Public Health, University of North Carolina, Chapel Hill. He is succeeded by Daniel A. Okun, who has been promoted to professor. Gilbert L. Kelso has been named associate professor of sanitary science. Dr. Baity, a North Carolina faculty member for 30 years, is presently serving as director of the Div. of Environmental Sanitation, World Health Organization, Geneva. Dr. Okun came to the university in 1952, on leave of absence from Malcolm Pirnie Engrs., New York, and Prof. Kelso was director of the Dept. of Field Training at the university's School of Public Health, on assignment from the US Public Health Service.

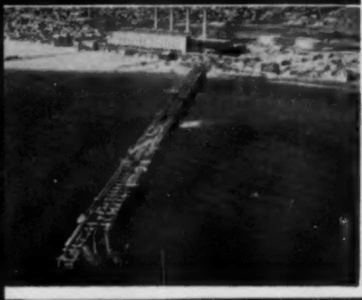
Ellis S. Tisdale, sanitary engineer director, has retired after 18 years with the US Public Health Service to become director of the Interstate Commerce Commission on the Potomac River Basin, Washington, D.C. Mr. Tisdale's most recent task with the USPHS was to assist in initiating a project for establishing a national register of sanitary engineers in the United States (*September 1955 P&R, p. 36*).

Ralph Estus has been appointed assistant sales manager for Hersey Mfg. Co., South Boston, Mass. Until recently Mr. Estus was manager of industrial sales for Fuller Brush Co., Hartford, Conn.

Edward G. Kominek has been promoted to general sales manager, Infilco Inc., Tucson, Ariz. Mr. Kominek has been with the company since 1937, the last 5 years as assistant sales manager.

(*Continued on page 90 P&R*)





(Continued from page 88 P&R)

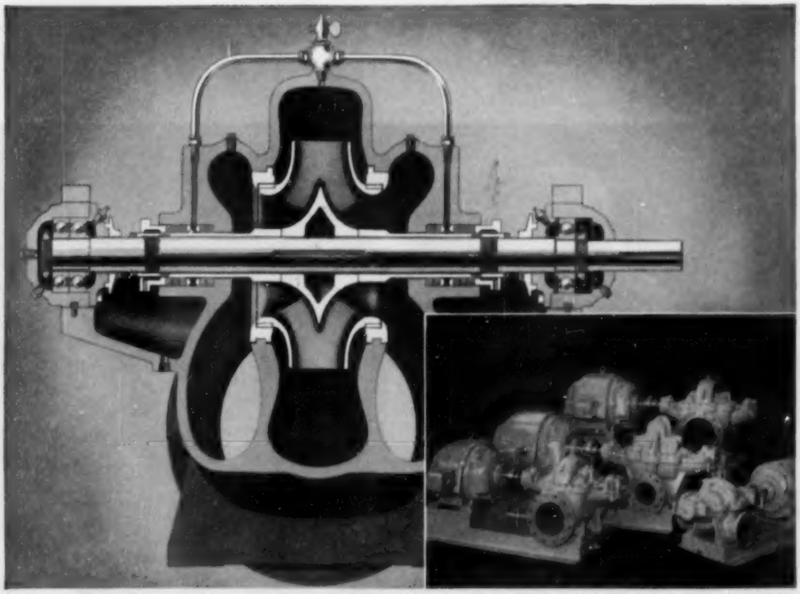
Edwin L. Oliver, founder-chairman of Dorr-Oliver Inc., died suddenly at his summer home at Lake Tahoe, Aug. 28, 1955, at the age of 77. A graduate of the University of California's College of Mines, his work in improving gold recoveries led to the development of the Oliver continuous filter in 1907. Mr. Oliver founded a company in 1910 to market this device. Subsequent expansion resulted in the formation of Oliver United Filters in 1928, with Mr. Oliver serving as president until the December 1954 merger with Dorr Co.

In recognition of his pioneering in and service to the metallurgical and process industries, Mr. Oliver was the recipient of many honors, notably the James Douglas Medal, most distinguished award of the American Institute of Mining & Metallurgical Engineers, and an honorary degree from the University of California.

Leon B. Reynolds, emeritus professor of hydraulic and sanitary engineering at Stanford University, died Sep. 26, 1955, at Palo Alto, Calif. He was 70 years old. Graduated from Stanford in 1909 with a degree in civil engineering, he joined the consulting firm of Burns & McDonnell, Kansas City, Mo., in that year, becoming a partner in 1920. He returned to Stanford to teach in 1923.

Prof. Reynolds joined AWWA in 1928. He was active in many other professional associations, including the American Public Health Assn., American Society of Civil Engineers, and the California Sewage Works Assn.

(Continued on page 94 P&R)



Cross Section Type M Pump. This construction is used, with minor variations, in all sizes 4" and larger.

Group of Double Suction Pumps ready for installation in municipal water works.

Worry-Proof

YOUR PUMPING PROBLEMS with WHEELER-ECONOMY PUMPS

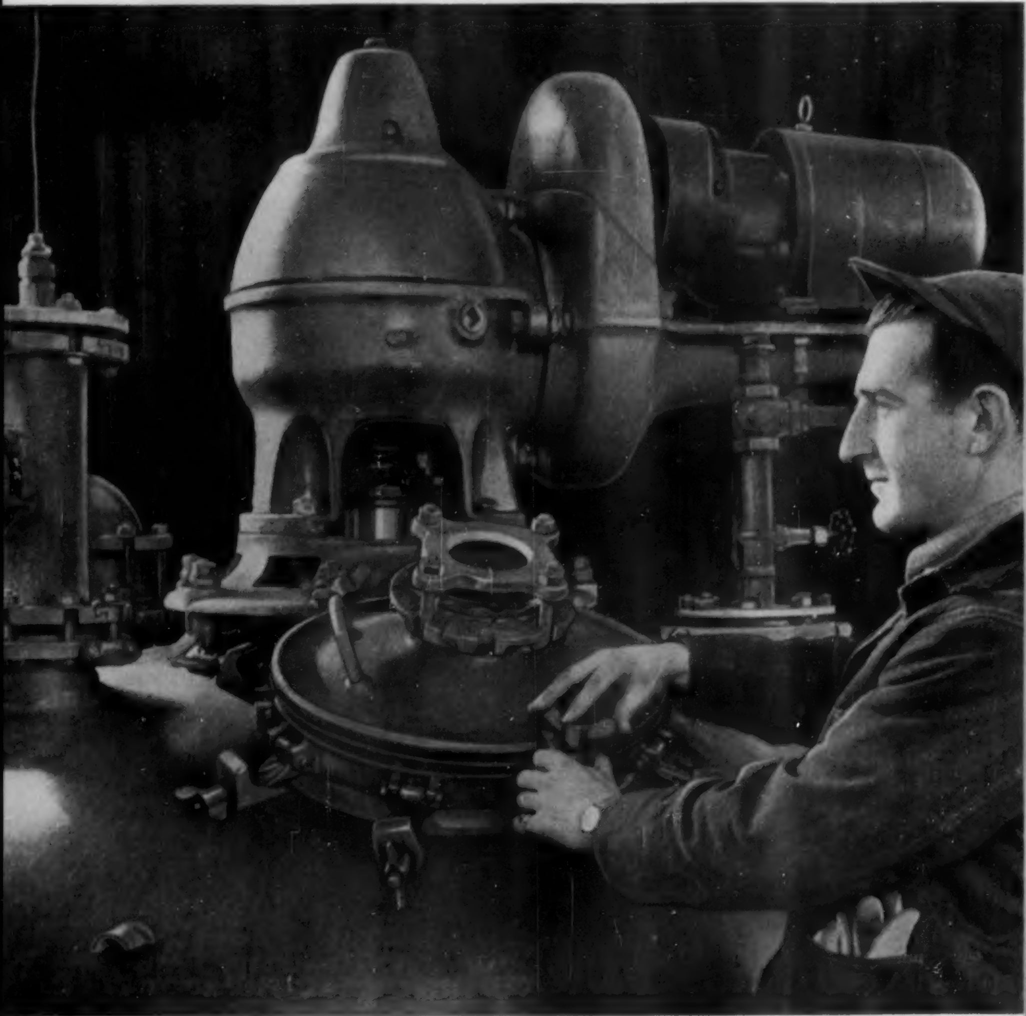
This cut-away section of a Wheeler-Economy Type "M" Pump shows engineering that means around-the-clock, around-the-calendar performance . . . peace of mind for the men in charge. Longer life and less maintenance work results from these important features . . . The method of supporting the rotor between outboard bearings with end-thrust practically eliminated . . . horizontally split casing with all pipe connections in lower half so that rotating parts can be removed without disturbing connections or pump alignment . . . Inlet designed to reduce leakage and friction losses . . . Double-bearing construction provides for longer packing life . . . Low pressure stuffing boxes . . . Wearing parts readily renewable.

To insure correct application for your municipal or industrial project, Wheeler-Economy offers specialized engineering service as well as a wide selection of pump sizes and cases. Write for CATALOG A-1052.

WE-512

WHEELER-ECONOMY PUMPS

ECONOMY PUMPS, INC. · DIVISION OF C. H. WHEELER MANUFACTURING CO.
19TH AND LEHIGH, PHILADELPHIA 32, PA.



Reaction kettle for making ion exchange resins at The Permutit Co., Birmingham, N. J.

(Continued from page 90 P&R)

Francis J. Sette, retired deputy director, Resources Div., Research & Development Board, US Dept. of Defense, died of a stroke on Jul. 20, 1955, at Gainesville, Fla. Born in 1898, Mr. Sette held degrees from Yale University's Sheffield Scientific School and from Harvard. He taught at several universities before entering government service with the Federal Resettlement Administration. Later he became deputy administrator of the Rural Electrification Administration. During World War II he was with the War Production Board and afterward the Civilian Production Board. He became an AWWA member in 1934.

Walter Spencer, superintendent-engineer, Merchantville-Pennsauken (N.J.) Water Commission, died Sep. 13, 1955, at the age of 65, after an illness of several weeks. Mr. Spencer served with the commission for 29 years, the last six as superintendent. He had recently been appointed for a second term to the New Jersey Board of Examiners for Water Treatment Plants.

A past-chairman of the New Jersey Section of AWWA, Mr. Spencer was also a member of the South Jersey Assn. of Water Company Superintendents, an organization which he helped found and of which he was secretary for 25 years. Other associations to which he belonged include the Society of American Military Engineers and the Inter-American Assn. of Sanitary Engineers.

CHANGES IN MEMBERSHIP

NEW MEMBERS

Applications received Sep. 1–30, 1955

Adams, C. V., City Mgr., Box 372, Fairburn, Ga. (Oct. '55)

Adams, William H., Supt. & Operator, Carol City Utilities Inc., 17900 N.W. 37th Ave., Carol City, Opalocka, Fla. (Oct. '55) *MP*

Alamo Iron Works, M. G. Voigt, Vice-Pres. & Mgr., Machinery Div., Box 231, San Antonio 6, Tex. (Assoc. M. Jul. '50)

Andersen, Carl C., Jr., Engr., Leo A. Daly Co., 633 Insurance Bldg., Omaha, Neb. (Oct. '55) *P*

Arizona Corporation Com., G. W. Harrell, Director of Utilities, 205 Capital Bldg., Phoenix, Ariz. (Corp. M. Oct. '55) *MRD*

Assar, Mohammad, Acting Chief, San. Eng. Div., Public Health Cooperative Organization, Tehran, Iran (Oct. '55) *MRD*

Backus, F. E., Dist. Repr., Darling Valve & Mfg. Co., 3835 Elmhurst Rd., Toledo, Ohio (Oct. '55) *MP*

Banner, J. T.; *see* Banner, J. T., & Assocs.

Banner, J. T., & Assocs., J. T. Banner, Rm. 201, Garlett Bldg., Laramie, Wyo. (Corp. M. Oct. '55) *PD*

Barngraver, Lester, Water Supt., 424 N. Kimberly, Shawnee, Okla. (Oct. '55)

Bauer, David J., Borough Mgr., Lititz, Pa. (Oct. '55) *M*

Beall, Roger W., Supt., Water & Gas Dept., Bainbridge, Ga. (Oct. '55)

Black, Thomas J., Engr., Thomas J. Black & Assocs., 17218 E. Warren Ave., Detroit 24, Mich. (Oct. '55) *PD*

Blair, Robert J., Vice-Pres., Chas. R. Haile & Assocs., Inc., 2801 San Jacinto St., Houston 4, Tex. (Oct. '55) *MRP*

Bogue, Stuart H., Asst. Design Engr., Pate & Hirn, 532 Michigan Bldg., Detroit 26, Mich. (Oct. '55) *RP*

Boney, James F., Civ. Engr., Wm. C. Olsen & Assocs., Box 271, Raleigh, N.C. (Oct. '55) *MRPD*

Bossier City, City of, Clyde W. Fowler, Comr. of Finance & Public Utilities, 630 Barksdale Blvd., Bossier City, La. (Munic. Sv. Sub. Oct. '55)

Boutte, Henry, Supt., Water & Sewage, Abbeville, La. (Oct. '55) *MRP*

Bradley, Eugene D., Sales Engr., Turbine Equipment Co., 3060 Bailey Ave., Buffalo, N.Y. (Oct. '55)

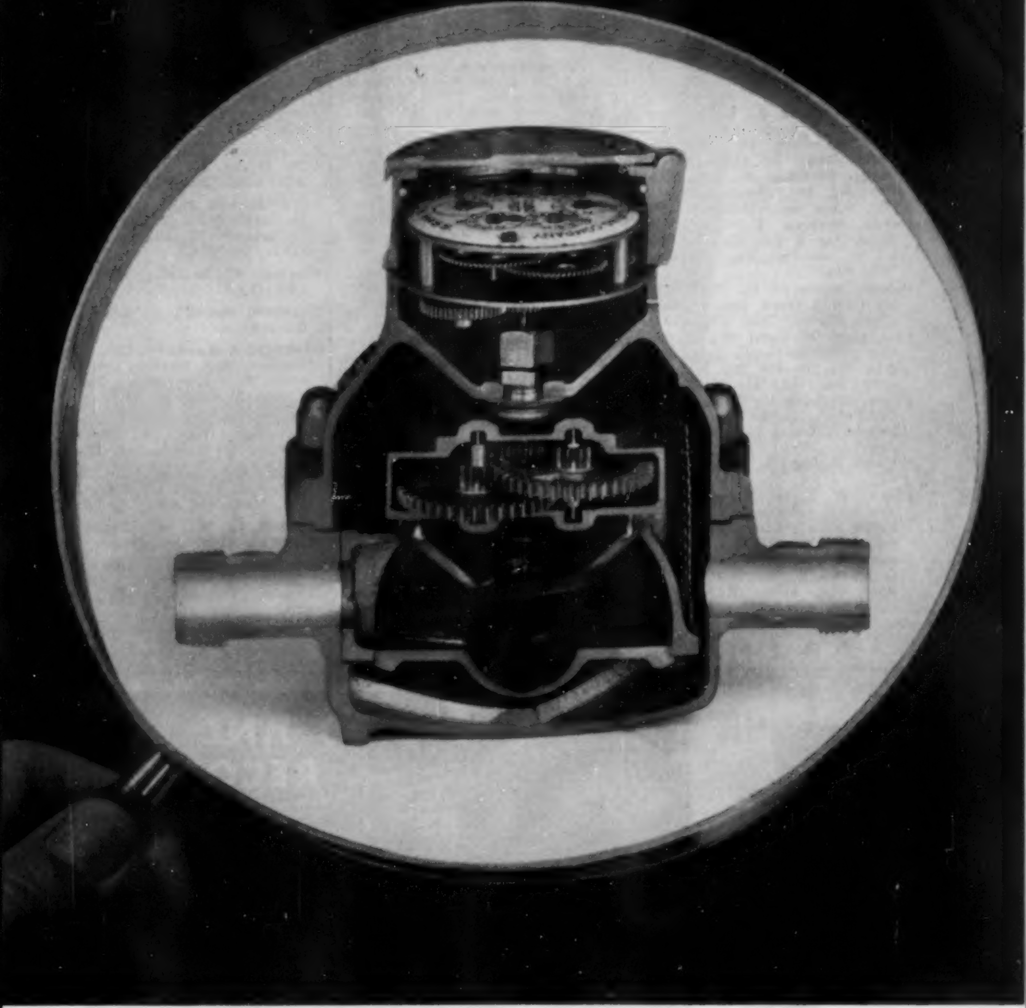
Braisted, William A., Sr. Engr., Barker & Wheeler, Engrs., 36 State St., Albany, N.Y. (Oct. '55) *RPD*

Brender, Edward G., Partner, Brender & Brender, Engrs., 35449 Annapolis St., Wayne, Mich. (Oct. '55) *MD*

Burrus, C. J., Jr., Gen. Mgr., Munic. Water System, Helena, Ark. (Oct. '55) *M*

Byrd, Kenneth D., Vice-Pres., J. W. Goodwin Eng. Co. Inc., 2111—7th Ave. S., Birmingham, Ala. (Oct. '55) *RPD*

(Continued on page 98 P&R)



(*Continued from page 96 P&R*)

Carter, J. P., Jr., Gen. Mgr., Carter Constr. Co., Geneva, Ala. (Oct. '55)

Carville, David J., Design Engr., Barnard & Burk, Cons. Engrs., 1023 Nicholson Dr., Box 268, Baton Rouge, La. (Oct. '55) *RP*

Cawley, William A., San. Engr., Rayonier, Inc., Jesup Div., Box 207, Jesup, Ga. (Oct. '55) *P*

Cayot, Ramon F., Civ. Engr., Pacific Gas & Elec Co., 245 Market St., San Francisco, Calif. (Oct. '55) *RPD*

Celoni, Leonard G., Supt., Oakley County Water Dist. Filtration Plant, Oakley, Calif. (Oct. '55) *P*

Chapman, Howard W., Regional Engr., Public Health Service Region IV, 50—7th St., N.E., Atlanta, Ga. (Oct. '55)

Clare, Herbert C., Sr. San Engr., US Public Health Service, Water Supply & Water Pollution Control Activities, Rm. 211, US Courthouse, Portland 5, Ore. (Oct. '55) *RP*

Clark, W. S. D., Foreman, Water Treatment, National Biscuit Co., Paper Mill & Carton Plant, Marseilles, Ill. (Oct. '55) *P*

Columbia Cellulose Co. Ltd., D. J. Rowse, Water Plant Foreman, Box 1000, Prince Rupert, B.C. (Corp. M. Oct. '55) *MRPD*

D'Angelo, Armand, Deputy Comr., Dept. of Water Supply, Gas & Electricity, Rm. 2355, Municipal Bldg., New York 7, N.Y. (Oct. '55) *M*

Dovel, James P., Constr. Engr., J. E. O'Toole Eng. Co., 317 Watts Bldg., Birmingham, Ala. (Oct. '55)

Dunbar, Crawford K., Civ. Engr., City-Parish Dept. of Public Works, Box 155, Baton Rouge, La. (Oct. '55) *PD*

Eberhardt, Richard W., Chemist, Coastal Eng. Corp., Box 11036, New Orleans, La. (Oct. '55) *P*

Echols, Jack W., Vice-Pres., J. W. Goodwin Eng. Co. Inc., 2111—7th Ave. S., Birmingham, Ala. (Oct. '55)

Ellis, C. Hoyt, Cons. Engr., 250 Brown Marx Bldg., Birmingham, Ala. (Oct. '55) *MRPD*

Enterkin, I. J., Jr., Supervisor, Water Supply & Sanitation, 6607th Installations Squadron, APO 23, New York, N.Y. (Oct. '55)

Esso Standard Oil Co., Louisiana Div., J. Clifton Hill, Engr., Tech. Div., Box 551, Baton Rouge, La. (Corp. M. Oct. '55) *RPD*

Eubank, Charles W., Exec. Asst., Leo A. Daly Co., 633 Insurance Bldg., Omaha, Neb. (Oct. '55) *RD*

Farthing, Charles Ray, Gen. Foreman, Water Production & Control, Public Service Dept., 164 W. Magnolia Blvd., Burbank, Calif. (Oct. '55)

Fitzgibbon, James M., Supt., Water Works, City Hall, Yonkers, N.Y. (Oct. '55) *MPD*

Ford, Joseph J., San. Engr., Water Safety, City of Chicago, 3300 Cheltenham Pl., Chicago 49, Ill. (Oct. '55) *MRP*

Fowler, Clyde W.; *see* Bossier City (La.)

Gardner, Henry; *see* Glenfield & Kennedy

Glenfield & Kennedy, Ltd., Henry Gardner, Mng. Director, Low Glencairn St., Kilmarnock, Scotland (Assoc. M. Oct. '55)

Gosney, Macauley J., Supt., Water Dept., 33001 Five Mile Rd., Livonia, Mich. (Oct. '55) *M*

Hardy, V. R., Technician, Water & Sewage, Patrick Air Force Base, Fla. (Oct. '55) *RP*

Harrell, G. W.: *see* Arizona Corporation Com.

Hartman, Paul J., Utility Rate Analyst, Water Dept., City Hall Annex, Philadelphia, Pa. (Oct. '55)

(*Continued on page 100*)

(*Continued from page 98*)

Hetch Hetchy Water Supply, H. E. Lloyd, Mgr. & Chief Engr., Power & Utilities Eng. Bureau, 425 Mason St., San Francisco, Calif. (Munic. Sv. Sub. Jul. '55) *MRP*

Hill, J. Clifton; *see* Esso Standard Oil Co., Louisiana Div.

Hopper, R. J., Pres., Trask Well Co., Ltd., 503 Maritime Bldg., New Glasgow, N.S. (Oct. '55)

Johnson, Lincoln; *see* Malone (N.Y.) Village Water Works

Kish, George D., Research Mgr., Dresser Mfg. Div., Bradford, Pa. (Oct. '55) *MR*

Kuebler, Chester L., Owner, Kuebler Pump Repair, 331 S. East St., Anaheim, Calif. (Oct. '55) *RD*

Lachlan, I. D., Comr., Greater Victoria Water Dist., 285 Yates St., Victoria, B.C. (Oct. '55) *M*

Lacy, R. R., Supt. of Production, Water Dept., Box 870, Fort Worth 1, Tex. (Oct. '55) *M*

Leonhard, Harold M., Chief Chemist, Wayne County Sewage Disposal & Water Supply System, 797 Central, Wyandotte, Mich. (Oct. '55) *MRPD*

Letz, Carey A., Jr., Dist. Repr., Inertol Co., 1103 First National Bank Bldg., Atlanta, Ga. (Oct. '55)

Libby, Roscoe W., San. Engr., Welly Air Force Base, Installations Div., Bldg. 73, San Antonio, Tex. (Oct. '55) *MR*

Likes, Tommy H., Partner, Burlington Plumbing & Heating Co., Burlington, Kan. (Oct. '55) *D*

Linaweaver, F. Pierce, Jr., Jr. Engr., Bureau of Water Supply, 2331 N. Fulton St., Baltimore 17, Md. (Jr. M. Oct. '55)

Lingel, Edward W., Asst. Chief, AC & W Navaids Div., Deputy for Installations, Alaskan Air Command, US Air Force, Hq. Sq., Hq. AAC, APO 942, Seattle, Wash. (Oct. '55) *MRP*

Lloyd, H. E.; *see* Hetch Hetchy Water Supply

Lopez, Alfredo, Engr., Dept. Cooperativo Interamericano de Obras de Salubridad, Huerfanos 1117, Santiago, Chile (Oct. '55) *MRP*

Madden, R. U., Mgr., Industrial Supply Dept., The Mine & Smelter Supply Co., Box 5270 Terminal Annex, Denver 17, Colo. (Oct. '55) *RD*

Malone Village Water Works, Lincoln Johnson, City Engr., Malone, N.Y. (Munic. Sv. Sub. Oct. '55) *MPD*

Marshall, Jim B., Supt., Water & Gas, Anahuac, Tex. (Oct. '55) *MRP*

Matthies, Fred J., Civ. Engr., Leo A. Daly Co., 633 Insurance Bldg., Omaha, Neb. (Oct. '55) *PD*

McBride, Clyde M., Engr., Turbine Equipment Co., Box 578, Westfield, N.J. (Oct. '55) *D*

Messick, Jerauld E., Civ. Eng. Assoc., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (Oct. '55) *D*

Monroe, Jack F., Supt., Water & Sewerage, 3307 Lee St., Greenville, Tex. (Oct. '55) *MP*

Moses, Walter B., Jr., Sales Engr., Eng. Sales Co., 171 Audubon Blvd., New Orleans 18, La. (Oct. '55) *P*

Oglesby, John H., Supt., Water Works, City Hall, Pecos, Tex. (Oct. '55) *M*

Petitt, Ben M., Jr., Engr. in Charge, US Geological Survey, 106 W. Market St., San Antonio 6, Tex. (Oct. '55) *R*

Presser, James L., Sales Repr., Hays Mfg. Co., 5356 Norwaldo, Indianapolis, Ind. (Oct. '55) *D*

(*Continued on page 102 P&R*)

(Continued from page 100 P&R)

Rowse, D. J.; *see* Columbia Cellulose Co.

Schertz, Walter A., Supt., Water Works, Schertz, Tex. (Oct. '55) *M*

Sinton, Preston S., Cons. Engr., 3619 Lexington Rd., Louisville 7, Ky. (Oct. '55) *PD*

Smith, Bernard C., Civ. Engr., 128 N. Main St., Minoa, N.Y. (Oct. '55) *RPD*

Smith, Burton D., Sales Mgr., Southern Cen-Vi-Ro Pipe Corp., Box 1205, Mobile, Ala. (Oct. '55) *M*

Smith, Earl G., Supt., Water, Heat & Disposal Plant, Worthington, Minn. (Oct. '55) *MRP*

Speed, Clyde M., Mgr., Harris County Water Control & Irrigation Dist. No. 36, 14403 Market Street Rd., Houston 15, Tex. (Oct. '55) *M*

Speeg, D. E., Chem. Engr., Coastal Eng. Corp., Box 11036, New Orleans 13, La. (Oct. '55) *PD*

Steffen, Bernard R., Owner-Operator, Anderson Water Co., Box 41, Anderson, Calif. (Oct. '55) *M*

Stiles, Robert L., State Repr., Mountain States Pipe & Supply Co., 433 E. Cocharras, Colorado Springs, Colo. (Oct. '55) *MD*

Stoddard, Robert J., Vice-Pres. & Gen. Mgr., Robert S. Stoddard & Co. Inc., 1115 E. Rosencrans Ave., Compton, Calif. (Oct. '55) *D*

Stordeur, Ambrose J., Supt., Water Dept., 208 N. Broadway, De Pere, Wis. (Oct. '55) *M*

Sturm, E. A., Chief Engr., Water Board Mission Sta., 501 E. Theo Ave., San Antonio, Tex. (Oct. '55) *R*

Sumner, Billy Taylor, 1123 Church St., Nashville 3, Tenn. (Oct. '55)

Tabor, James Milton, Asst. Supt., City of Southside Place, 6309 Edloe, Houston 5, Tex. (Jul. '55) *M*

Thompson, John F., Mgr., Morrilton Water Co., Morrilton, Ark. (Oct. '55) *M*

Toccoa Water Dept., Albert Brown, Filter Plant Operator, Box 206, Toccoa, Ga. (Munic. Sv. Sub. Jul. '55) *PD*

Todd, Liston F., Water Supt., Albany, Tex. (Oct. '55) *MP*

Trudeau, J. Gaetan, Field Engr., Water & Sewers Div., City Hall, Montreal, Que. (Oct. '55)

Utility Analysis, Inc., A. J. Rourke, Pres., Suite 241, 245 S.E. 1st St., Miami, Fla. (Corp. M. Jul. '55) *MRP*

Van Meter, William J., Property Mgr., St. Vincent Hospital, Santa Fe, N.M. (Jul. '55) *RP*

Vargas, Jorge R., Field Engr., El Paso County Water Control & Improvement Dist. No. 1, Box G, Ysleta, Tex. (Jul. '55)

Viana, Hugo I., Graduate Student, Massachusetts Inst. of Technology, Cambridge, Mass. (Jul. '55) *PD*

Voigt, M. G.; *see* Alamo Iron Works

Watkins, Robert E., Water Chemist, South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jul. '55) *RP*

Watts, Paul B., Sales Engr., Mueller Co., Decatur, Ill. (Oct. '55)

Weirback, Stanley L., Field Engr., Fischer & Porter Co., 6717 W. 87th St., Oak Lawn, Ill. (Oct. '55) *MRP*

Weisert, Robert H., Repr., The Harco Corp., 7715 N. Sheridan Rd., Chicago, Ill. (Jul. '55)

Williamson, A. E., Contracting Engr., Chicago Bridge & Iron Co., 460 Alcoa Bldg., Pittsburgh, Pa. (Oct. '55) *D*

Williamson, Kenneth M., Contracting Engr., Pittsburgh-Des Moines Steel Co., 679 First National Bank Bldg., Chicago, Ill. (Oct. '55)

Wright, C. P., Pres., Steel City Construction Co., Box 5707, Birmingham 9, Ala. (Oct. '55)

Index of Advertisers' Products

Activated Carbon:
Industrial Chemical Sales Div.
Permutit Co.

Aerators (Air Diffusers):
American Well Works
Carborundum Co.
General Filter Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Air Compressors:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Morse Bros. Mchy. Co.

Alum (Sulfate of Alumina):
American Cyanamid Co., Heavy Chemicals Dept.
General Chemical Div.

Ammonia, Anhydrous:
General Chemical Div.

Ammoniators:
Fischer & Porter Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Co., Inc.

Brass Goods:
American Brass Co.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Carbon Dioxide Generators:
Infilco Inc.
Walker Process Equipment, Inc.

Cathodic Protection:
Electro Rust-Proofing Corp.
Harco Corp.

Cement Mortar Lining:
Centriline Corp.

Chemical Feed Apparatus:
Fischer & Porter Co.
Cochrane Corp.
Graver Water Conditioning Co.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Chemists and Engineers:
(See Professional Services)

Chlorination Equipment:
Builders-Providence, Inc. (Div., B-I-F Industries)
Everson Mfg. Corp.
Fischer & Porter Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Chlorine Comparators:
Klett Mfg. Co
Wallace & Tiernan Inc.

Chlorine, Liquid:
Wallace & Tiernan Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
Mueller Co.
Rensselaer Valve Co.
Skinner, M. B., Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.
Skinner, M. B., Co.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
Skinner, M. B., Co.
Trinity Valley Iron & Steel Co.

Clarifiers:
American Well Works
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Cleaning Water Mains:
Flexible Inc.
National Water Main Cleaning Co.

Condensers:
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
General Filter Co.
Infilco Inc.
Penn Industrial Instrument Div.
Simplex Valve & Meter Co.

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Phelps Dodge Refining Corp.
Tennessee Corp.

Corrosion Control:
Calgon, Inc.
Philadelphia Quartz Co.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Philadelphia Gear Works, Inc.

Diaphragms, Pump:
Dorr-Oliver Inc.
Morse Bros. Mchy. Co.
Southern Pipe & Casing Co.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Professional Services)

Feedwater Treatment:
Allis-Chalmers Mfg. Co.
Calgon, Inc.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Carborundum Co.
General Filter Co.
Johns-Manville Corp.
Infilco Inc.
Northern Gravel Co.
Permutit Co.
Carl Schleicher & Schuell Co.
Stuart Corp.

Filters, incl. Feedwater:
Cochrane Corp.
Dorr-Oliver Inc.
Graver Water Conditioning Co.
Infilco Inc.
Morse Bros. Mchy. Co.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filters, Membrane (MF)
AG Chemical Co.
Millipore Filter Corp.
Carl Schleicher & Schuell Co.

Filtration Plant Equipment:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chain Belt Co.
Cochrane Corp.
Filtration Equipment Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Roberts Filter Mfg. Co.
Stuart Corp.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
Carlon Products Corp.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:
American Agricultural Chemical Co.
Blockson Chemical Co.

Fluoride Feeders:
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Infilco Inc.
Penn Industrial Instrument Div.
Simplex Valve & Meter Co.

Gages, Loss of Head, Rate of Flow, Sand Expansion:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Infilco Inc.
Penn Industrial Instrument Div.
Simplex Valve & Meter Co.

Gasholders:
Chicago Bridge & Iron Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Morse Bros. Mchy. Co.
Mueller Co.
R. D. Wood Co.

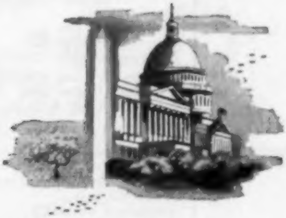
Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Klett Mfg. Co.
Wallace & Tiernan Inc.
Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.
Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.
Hydrogen Ion Equipment:
Wallace & Tiernan Inc.
Ion Exchange Materials:
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Iron, Pig
Woodward Iron Co.
Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Jointing Materials:
Hydraulic Development Corp.
Johns-Manville Corp.
Leadite Co., Inc.
Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.
Leak Detectors:
Jos. G. Pollard Co., Inc.
Lime Slakers and Feeders:
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries)
Permutit Co.
Magnetic Dipping Needles:
W. S. Darley & Co.
Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.
Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Worthington-Gamon Meter Co.
Meter Reading and Record Books:
Badger Meter Mfg. Co.
Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.
Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Foster Eng. Co.
Infilco Inc.
Penn Industrial Instrument Div.
Simplex Valve & Meter Co.
Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.
Mixing Equipment:
Chain Belt Co.
General Filter Co.
Infilco Inc.
Paints
Inertol Co., Inc.
Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.
Pipe, Brass:
American Brass Co.
Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.
Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.
Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Pipe, Copper:
American Brass Co.
Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.
Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.
Pipe Cutters
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
Reed Mfg. Co.
A. P. Smith Mfg. Co.
Spring Load Mfg. Corp.
Pipe Jointing Materials; see Jointing Materials
Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.
Pipe Vises
Spring Load Mfg. Corp.
Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Potassium Permanganate
Carus Chemical Co.
Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.
Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Morse Bros. Mchy. Co.
C. H. Wheeler Mfg. Co.
Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.
Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Pumps, Diaphragm:
Dorr-Oliver Inc.
Morse Bros. Mchy. Co.
Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.
Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.
Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.
Pumps, Sump:
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.
Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Fischer & Porter Co.
Permutit Co.
Wallace & Tiernan Inc.
Recording Instruments:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Infilco Inc.
Penn Industrial Instrument Div.
Wallace & Tiernan Inc.
Reservoirs, Steel:
Chicago Bridge & Iron Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.
Sand Expansion Gages; see Gages
Sleeves; see Clamps
Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Sludge Blanket Equipment:
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.
Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.
Sodium Silicate
Philadelphia Quartz Co.
Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

WASHINGTON, D. C.

PREFERS

Concrete Pressure Pipe



The District of Columbia, home of the Nation's capitol, recognizes the advantages of concrete pressure pipe. From 1925 to the present, over 175,000 feet of concrete pressure pipe have been installed in this congested 69 square mile area. Pipe diameters range from 20" to 78", with heads from 70 up to 450 feet. A substantial part of this footage is in use in the Washington, D. C. distribution system.

Washington engineers consider economy and length of service of primary importance when specifying water pipe . . . also, high carrying capacity, and ease of installation. Because concrete pressure pipe meets these and other exacting requirements, it has been selected time and again for new supply mains and extensions to the distribution lines.

If your community is planning additional water lines, or replacements for old lines, check into the advantages of concrete pressure pipe. It is available in diameters from 12" to over 12', for high or low heads, and can be installed to fit your individual requirements.

Member companies are equipped to manufacture and furnish concrete pressure pipe in accordance with established national specifications and standards.

Concrete PRESSURE Pipe

WATER FOR GENERATIONS TO COME

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 North LaSalle Street
Chicago 1, Illinois

Softening Chemicals and Compounds:
Calgon, Inc.
Cochrane Corp.
General Filter Co.
Infilco Inc.
Morton Salt Co.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries)
Cochrane Corp.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tenoning Tools
Spring Load Mfg. Corp.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Shower Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Shower Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Penn Industrial Instrument Div.
Simplex Valve & Meter Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.